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LR-30777 DOT/FAA/CT-85-10 DTFA03-83-C-00004

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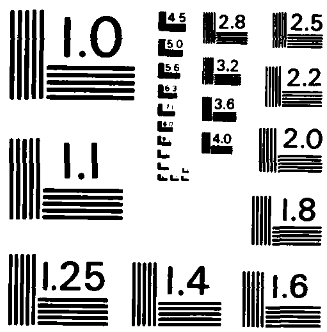

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

12

DOT/FAA/CT-85/10
Technical Center
Atlantic City Airport,
N.J. 08405

KRASH 85 User's Guide — Input/Output Format

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Prepared by
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Burbank, California

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Final Report

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16. Abstract

This document describes program KRASH as modified under Contract DTFA03-84-C-00004. updated version is denoted KRASH85. This document is a User's Guide and defines input and output formats appropriate for KRASH85.

Features that are incorporated into KRASH85 include:

- An improved plastic hinge moment algorithm,
- Gear-oleo metering pin coding,
- Load-interaction curves,
- An expanded initial conditions subroutine (combined with NASTRAN)
- A comprehensive energy balance,
- Center of gravity (c.g.) displacement, velocity, acceleration and force time histories,
- Revised vertical beam orientation coding,
- Provision to save data for post-processing i.e., acceleration, mass location and forces,
- Provisions to input preprocessed data,
- A corrected uncoupled KR curve unloading/reloading algorithm
- Provisions to define a tire spring (remains normal to the ground plane)
- Provisions to number the masses to an arbitrary sequence
- An option to compute section shear and moment distributions

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Computer program, KRASH, crash dynamics, nonlinear analysis, hybrid approach, aircraft, transport airplanes, general aviation aircraft, rotary wing aircraft, NASTRAN

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FOREWORD

This report was prepared by the Lockheed-California Company under Contract DTFA03-84-C-00004. The report contains a description of the effort performed as part of Tasks II, III and IV and covers the period from January 1984 to September 1984. The work was administered under the direction of the Federal Aviation Administration with L. Neri acting as Technical monitor.

The program leader was Gil Wittlin of the Lockheed-California Company. M. A. Gamon and W. L. LaBarge of the Lockheed-California Company refined program KRASH. P. Rohrer of the Lockheed-California Company provided valuable computer programming support. The Lockheed effort was performed in the Flutter and Dynamics Department.

TECHNICAL SUMMARY

This document describes program KRASH as modified under Contract DTFA03-84-C-00004. The updated version is denoted KRASH35. This document is a User's Guide and defines the input and output formats appropriate for KRASH85.

Features that are incorporated into KRASH85 include:

- An improved plastic hinge moment algorithm
- Gear-oleo metering pin coding
- Load-interaction curves
- An expanded initial conditions subroutine (combined with NASTRAN)
- A comprehensive energy balance
- Center of gravity (c.g.) displacement, velocity, acceleration and force time histories
- Revised vertical beam orientation coding
- Provision to save data for post-processing i.e., acceleration, mass location and forces
- Provisions to input preprocessed data
- A corrected uncoupled KR curve unloading/reloading algorithm
- Provisions to define a tire spring (remains normal to the ground plane)
- Provisions to number the masses in an arbitrary sequence
- An option to compute section shear and moment distributions

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EXECUTIVE SUMMARY

Program KRASH, originally developed under Federal Aviation Administration sponsorship for predicting the response of general aviation airplanes to an impact environment, has been enhanced to include features that would facilitate the modeling of transport category airplanes. This document is the User's Guide which defines the input and output formats appropriate for this new version of Program KRASH known as KRASH 85.

SECTION 1

INTRODUCTION

Program KRASH, developed under a previous Federal Aviation Administration (FAA) sponsored contract DOT-FA75-WA3707 has been in the public domain since 1979. In subsequent years changes to enhance its usage have occurred. Recently, KRASH has been applied to modeling transport airplanes for impact conditions. Many of the recent program changes that have occurred are designed to facilitate modeling transport airplanes. The following modifications have been incorporated into KRASH85 and used recently to model transport category aircraft:

- Improved plastic hinge moment algorithm
- Gear oleo metering pin
- Load interaction curves
- Expanded Initial Condition Subroutine
- Arbitrary numbering of lumped mass points

Other modifications provide general enhancement capability and include:

- Comprehensive energy balance
- Computation of c.g. time histories
- Revised vertical beam orientation coding
- Post Processing of data, i.e., acceleration, mass location and forces
- Corrected uncoupled KR curve unloading/reloading algorithm

In addition, miscellaneous coding corrections have been made. The current version is denoted KRASH85.

This document is the User's Guide and is limited to a description of the input-output format for KRASH85.

SECTION 2

USER'S GUIDE

2.1 OVERALL KRASH85 ANALYSIS SYSTEM

The overall KRASH85 analysis system consists of two separate KRASH programs called KRASHIC and KRASH85, plus a NASTRAN program denoted herein as MSCTRAN. The NASTRAN program used in this system is MSC/NASTRAN Version 63 (Aug 1, 1983). KRASHIC and MSCTRAN are used only if balanced initial conditions are required; KRASH85 is the normal KRASH time-history program. If KRASHIC and MSCTRAN are not used, then at time zero the beams in the analytical model will all have zero internal deflections and loads. The model will be located just above the ground and in the proper attitude, as specified in the input data. This initial balance is acceptable for certain types of problems, primarily those in which the aerodynamic loads on the vehicle are zero. For that situation, the lumped masses in the model are all accelerating downward at 1g (free-falling), and the internal beam loads and deflections are actually zero.

If nonzero aerodynamic forces are present, then the initial beam loads and deflections are not zero. Nevertheless, execution of KRASH85 by itself will automatically set the beam loads and deflections at zero. If this is done with nonzero aerodynamic forces, the system will be out of balance at time zero. In this situation, the dynamic response will be the result of two phenomena:

- Dynamic response to the ground impact
- Dynamic response to the initial imbalance

The latter response is not desired, and can obscure the desired response or confuse the interpretation of the output data. The proper solution of this problem requires that the analytical model be in equilibrium at time zero with nonzero internal beam loads and compatible deflections.

This is essentially a straightforward static loads analysis problem. NASTRAN is used to solve the statics problem, and KRASHIC is used to read KRASH85 input data and convert it into NASTRAN Executive Case Control and Bulk Data Decks. Figure 2-1 shows a flow diagram for the overall KRASH85 analysis system. The options available to the user include the following:

1. Run step 1 only (program KRASHIC)

2. Iterate steps 1 and 2, N times (user-specified)

3. Iterate steps 1 and 2, N times, then run step 3 (KRASH85)

4. Run step 3 (KRASH85) only

The most general case is option 3. The iterations are required for the following reasons. The static solution used in MSCTRAN is Rigid Format 24, which is a small deflection linear static analysis. This method actually assumes zero deflections for the purposes of calculating transformation matrices for transforming beam loads from beam element axes to the global axis system, which in this case are airplane axes. Therefore, if the deflections from MSCTRAN are used to relocate the KRASH85 mass points, the KRASH85 calculated beam loads will be proper in beam axes, but when resolved to mass axes will yield a system that is out of balance (since KRASH85 does not assume the deflections are zero when calculating the transformation matrices)

The solution to this problem is to iterate steps 1 and 2, using the calculated deflections from MSCTRAN to relocate the mass and node points in KRASH at each step. Satisfactory convergence is achieved after about six iterations, and additional accuracy can be achieved by using up to ten iterations. Beyond ten iterations, no further improvement in accuracy can be achieved due to the limitations in the number of digits that are written to the data sets that form the input and output of MSCTRAN.

The KRASH analysis system shown in figure 2-1 is implemented through Job Control Language (JCL). A job submittal using option 3 with six iterations causes a total of 13 sequential jobs to be executed (6 KRASHIC, 6 MSCTRAN and 1 KRASH85). While this may sound rather expensive, a typical case

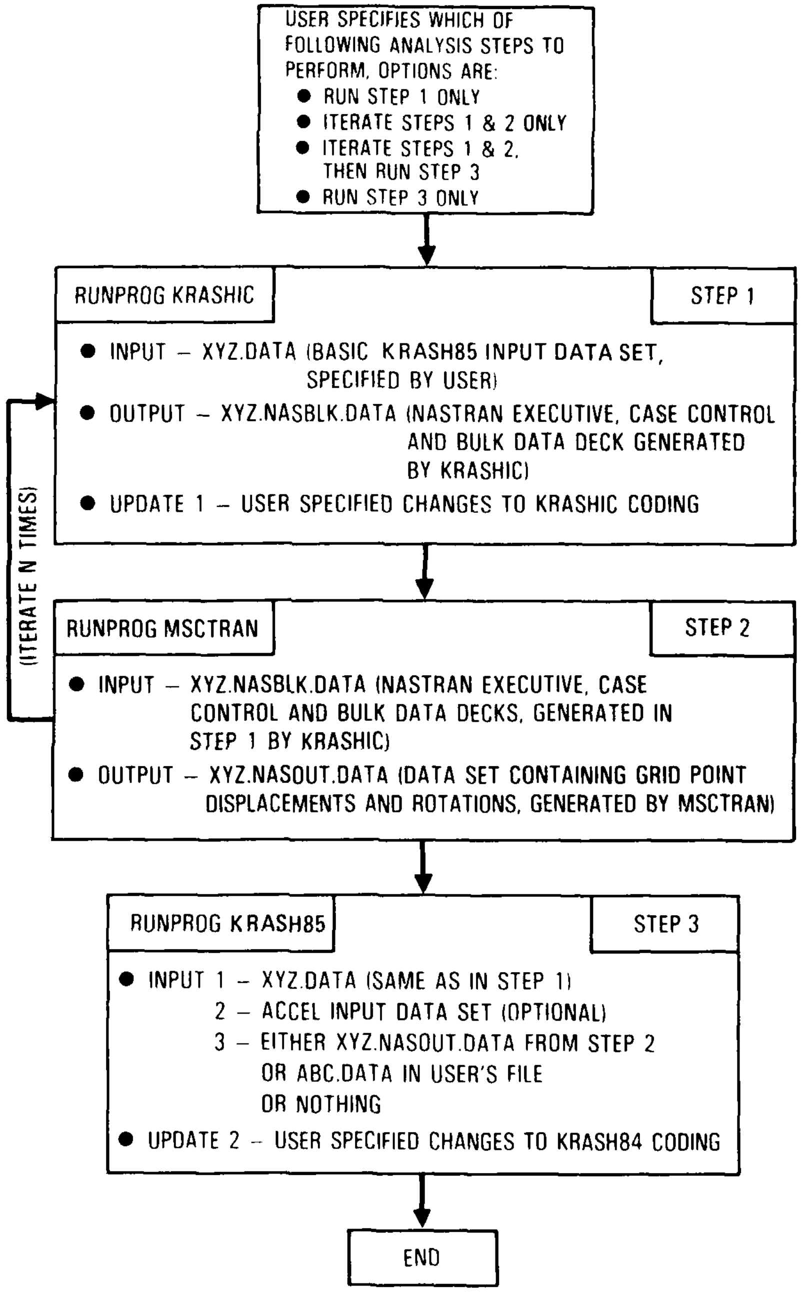

FIGURE 2-1. OVERALL KRASH85 ANALYSIS SYSTEM

(21 mass/27 beam, ½ airplane model) requires only about seven seconds per iteration on an IBM 370/3081, so that the iterated balanced loads can be determined in less than one minute. The JCL is set up so that data sets XYZ.NASBLK.DATA and XYZ.NASOUT.DATA are generated and named automatically, so the process is essentially invisible to the user.

Step 3 (KRASH85) can be executed separately using option 4. When this is done, the user has a choice of what to do for initial conditions. He can specify any data set in his library, or use nothing at all. The latter corresponds to the mode of execution for prior versions of KRASH. Once an initial condition data set (XYZ.NASOUT.DATA) has been generated, the user can execute step 3 only while specifying XYZ.NASOUT.DATA for initial conditions. This will give a valid initial balance as long as modifications to the basic data set (XYZ.DATA) are restricted to items that do not affect the initial balance.

The static loads problem could have been solved entirely within program KRASH, avoiding the complexity of achieving the system shown in figure 2-1 with JCL. However, the technique chosen has the advantage of automatically generating a NASTRAN model from a given KRASH Model. Since XYZ.NASBLK.DATA is a complete NASTRAN input data set in the user's library, the user can easily edit this data set to exercise other NASTRAN capabilities. Examples of other NASTRAN features that could prove useful include eigenvalue calculations and model plotting.

Figure 2-2 is a copy of the informaton displayed on a computer terminal during an option 3 run submittal. The items enclosed in rectangular brackets are the user responses. These are now discussed in detail. Some of the comments are of necessity applicable only to the Lockheed IBM 370/3081 installation, but are included to give some perspective on an actual application.

User Response	Description
runprog krashi x(1)	This is the initial command to invoke the Krash analysis system in Figure 2-1.

```
runprog P6489 x(1)

ENTER TIME
10
ENTER LINES
50
WOULD YOU LIKE EXPRESS, STANDARD
OR DEFERRED(VERNIGHT) TURNAROUND
FOR YOUR JOB? ENTER E, S OR D
d
Enter number

1   run KRASHIC only
2   iterate KRASHIC and MSCTRAN only
3   iterate KRASHIC and MSCTRAN, then run KRASH85
4   run KRASH85 only
3
Enter name of input data
b720 iciter data
Enter the number of times to cycle through
                   KRASHIC and MSCNASTRAN
10

print execution results only for
      the last iteration? (Y/N)

y

are you using B720.ICITER.NASOUT.DATA
   with the input data for the 1st iteration? (Y/N)

n
KRASHIC ITERATION #1

If temporary source changes then enter name
    of PAN updata data set.
    If none hit enter.
kic.kvb.data
Suppress compile listing ? (Y/N)
y

KRASHMSC ITERATION # 1
KRASHIC ITERATION # 2
KRASHMSC ITERATION # 2
```

FIGURE 2-2. SAMPLE KRASH85 JOB SUBMITTAL (SHEET 1 OF 2)

```
KRASHIC ITERATION # 3
KRASHMSC ITERATION # 3
KRASHIC ITERATION # 4
KRASHMSC ITERATION # 4
KRASHIC ITERATION # 5
KRASHMSC ITERATION # 5
KRASHIC ITERATION # 6
KRASHMSC ITERATION # 6
KRASHIC ITERATION # 7
KRASHMSC ITERATION # 7
KRASHIC ITERATION # 8
KRASHMSC ITERATION # 8
KRASHIC ITERATION # 9
KRASHMSC ITERATION # 9
KRASHIC ITERATION # 10
KRASHMSC ITERATION # 10

               KRASH84

is this a checkpoint/restart run?  (Y/N)
[n]

If temporary source changes then enter name of
    update data set
    If not then hit enter
[k83.icrc.data]

HIT "RETURN" KEY IF NO DATA SET:

(A) enter name of 2nd input data set of MASS ACCELERATIONS
    [DSA]

(b) enter name of output data set of MASS ACCELERATIONS
    [DSB]

(c) enter name of MASS and/or NODE POINT DISPLACEMENTS
    [DSC]                    (GRAPHICS POST PROCESSOR DATA)

How many copies of the printed output do you want?
1
SUPPRESS COMPILE LISTING ? (Y/N)
y
JOB E434367L SUBMITTED BY USER E434367
READY
```

FIGURE 2-2. SAMPLE KRASH85 JOB SUBMITTAL (SHEET 2 OF 2)

User Response	Description
10	Time limit for run = 10 minutes (actual execution time was less than three minutes)
50	Output print limited to 50000 lines (actual output is 21000 lines, about 1.5 inches thick).
d	Overnight (deferred) turnaround requested. (For runs less than 10 minutes, express turnaround is allowed. Results available within one to two hours).
3	Option 3 is chosen.
B720.ICITER.DATA	Basic KRASH85 input data set. This corresponds to XYZ.DATA in figure 2-1.
10	Number of iterations of steps 1 and 2.
y	Printout of KRASHIC and MSCTRAN is suppressed for the first nine iterations. Only the results for the last iteration are printed. Considerable output print will be generated if the results for all iterations are printed. (y = yes)
n	It is possible to start the first iteration with an existing data set of NASTRAN output deflections. For example, five iterations could be run at one time, and five more at a later time. This option was not invoked for this example. (n = no)
kic.kvb.data	This is the name of a PANVALET update data set which is used to revise the source code for KRASHIC. If no revisions are specified, then hit carriage return (CR).
y	A compiled listing of the subroutines changed in the previous step can be obtained. In the example, the listing is suppressed. (y = yes)
-	The terminal displays KRASHMSC ITERATION #1, etc., as the JCL for the sequential runs is being generated.
n	The checkpoint/restart capability of KRASH85 is not used for this run. (n = no)

User Response	Description
k83.icre.data	This is the name of a PANVALET update data set which is used to revise the source code for KRASH85. If no revisions are specified, then hit carriage return (CR).
DSA DSB DSC	In the example shown, the CR was hit for each of these, so no data sets were specified. DSA, DSB, and DSC are indicated here to illustrate where these are specified in the input. DSA, DSB, and DSC are described in the input format description.
1	One copy of the output print requested.
y	A compiled listing of the subroutines of KRASH85 that are revised can be obtained. In this example, the listing is suppressed. (y = yes)

The KRASH85 analysis system described herein is capable of achieving a balanced set of initial conditions <u>only</u> for the situation where the airplane starts completely off the ground. If any part of the airplane is initially in contact with the ground (any external springs initially deflected), the current code cannot balance the airplane.

2.2 INPUT

The input data format is described in detail in this section and is shown in table 2-1 and figure 2-3. Table 2-1 gives a quick overview of the input data sequence, while figure 2-3 is a complete layout of the input data format. The data discussed in this section correspond to XYZ.DATA in Section 2.1. Unless otherwise specified, all quantities are input to inch, pound, second, and radian units. Two formats are used for the majority of the data; 7E10.0 for fixed-point and scientific-notation input, and I5 for integers. As an exmaple of the former, the number 126.08 can be input in the following ways:

		1	2	6	.	0	8		
		1	2	6	.		8		

	1	.	2	6	0	8		E	2
	1	2	6	0	8	.	E	-	2

TABLE 2-1. KRASH INPUT FORMAT SEQUENCE

Card Sequence No.(s)	Required (R) or Optional (O)	Card Type Identifier	Identifier is Specified on Card No.	General Description of Data
10-170	R	–	–	Title, case control, initial conditions
200	R	NM	40	Mass data
300	O	NNP	40	Node point data
400	O	NTAB	70	Acceleration transfer correspondence data
500	O	NMSAV	80	Mass acceleration save data
600	O	NNPSAV	80	Node point acceleration save data
700-800	O	NSP	40	External spring data
900	R	NB	40	Internal beam data
1000	O	NMTL	40	Material data
1100	O	NPIN	40	Beam pinned-end and plastic hinge data
1200	O	NUB	40	Unsymmetrical beam data (axial only)
1290-1500	O	NOLED	40	Oleo type beam element data
1600	R	–	–	Internal beam damping ratio
1700	O	ND	40	Non-standard internal beam damping ratios
1800-1900	O	NLB	40	Nonlinear beam data (KR tables)
2000	O	MVP	40	Mass penetration volume definition
2100	O	NDRI	40	Dynamic Response Index (DRI) definitions
2200	O	NVCH	40	Volume change data
2300	O	NVBM	50	Non-standard maximum positive beam deflections.
2400	O	NVBMN	50	Non-standard maximum negative beam deflections.
2500	O	NFBM	50	Non-standard maximum positive beam loads
2600	O	NFBMN	50	Non-standard maximum negative beam loads
2700	O	NSCV	60	Sign convention vectors for load-interaction curves
2800-3000	O	NLIC	60	Load-interaction curve data
3100	O	NHI	50	Non-zero mass angular momenta, lift constant, or inertia cross products
3200	O	NPH	50	Non-zero initial mass orientation Euler angles
3300	O	NAERO	50	Mass aerodynamic data
3400-3500	O	NACC	40	Mass acceleration or load input time-histories
3600	O	NKM	50	Direct input of beam stiffness matrices
3700-3800	O	NPLT	140	Position plot data
3900	O	NMEP	140	Mass point printer plot data
4000	O	NNEP	140	Node point printer plot data
4100	O	NBFP	140	Beam loads printer plot data
4200	O	NBDP	140	Beam deflection printer plot data
4300	O	NSTP	140	Beam stress ratio printer plot data
4400	O	NSEP	140	External spring load/deflection printer plot data
4500	O	NENP	140	Beam strain/damping energy printer plot data
4600	O	NDRP	140	DRI printer plot data
4700	R	–	–	End of data set card

GENERAL PURPOSE DATA SHEET

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TITLE: KRASH85 INPUT FORMAT						PAGE 1	OF 7
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP		
				W.O.	EWA	ID	SEQ

1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–72	73–76	77–80
TITLE		CARD														10
TITLE		CARD														20
12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12345	67890	12		30
DUMMY																
NM	NSP	NB	NLB	NNP	NPIN	NUB	NORI	NOLEO	NACC	MVP	NVCH	NMTL	ND			40
DUMMY																
NVBM	NFBM	NVBMN	NFBMN	NKM	NHI	NPH	NTOL1	NTOL2	NTOL3	NSC	NIC	NAERO	NBOMB			50
DUMMY																
NSCV	NLITC	NWRGRA	NBAL	ICD	ICITER											60
DUMMY																
(CSIN)		(RNIN)		NTAB												70
(CSOUT)		(RNOUT)		NMSAV		NNPSAV		NDTSAV		NWRFLG		NDTGRA				80
DUMMY																
CASEIN		RUNIN		MSECIN												90
CASEOUT		RUNOUT		MSCOUT(1)		MSCOUT(2)		— —		— —						100
DUMMY																
DP/DT		DT		TMAX		PLOWT		FCUT		RUNMOD						110
DUMMY																
		BLANK		CARD												120

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 1 OF 7)

GENERAL PURPOSE DATA SHEET

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PAGE 2 OF 7

TITLE:

PREPARED BY	DATE	CHECKED BY	DATE	JOB NO. / W.O.	GROUP / EWA	ID	SEQ

1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-72	SEQ
DUMMY															
NSF	NTF	NDE	NSPD	NED	NS	NRP	NIMP	NBC							130
DUMMY															
NMEP	NNEP	NBFP	NBDP	NSTP	NSEP	NENP	NDRP	NPLT	NPFCT						140
DUMMY															
XGDOT		YGDOT		ZGDOT											150
PPR		QPR		RPR											160
PHIPR		THEPR		PSIPR		XGIN		ZGIN		BETA		RHO			170
DUMMY		(NM CARDS FOLLOW)													
WGT(I)		XDP(I)		YDP(I)		ZDP(I)		XI(I)		YI(I)		ZI(I)		ID	200
DUMMY		(NNP CARDS FOLLOW)													
MNP(I)	INP(I)	XNPDP(I)		YNPDP(I)		ZNPDP(I)									300
DUMMY		(NTAB CARDS FOLLOW)													
IS_{NEW}	MS_{NEW}	LS_{NEW}	IS_{OLD}	MS_{OLD}	LS_{OLD}	TSH									400
DUMMY		(NMSAV CARDS FOLLOW)													
X	ISAV	MFL_1	MFL_2	MFL_3	MFL_4	MFL_5	MFL_6	MFL_7	MFL_8	MFL_9					500
DUMMY		(NNPSAV CARDS FOLLOW)													
NNPSAV	INPSAV	$NPFL_1$	$NPFL_2$	$NPFL_3$	$NPFL_4$	$NPFL_5$	$NPFL_6$	$NPFL_7$	$NPFL_8$	$NPFL_9$					600

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 2 OF 7)

GENERAL PURPOSE DATA SHEET

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TITLE:						PAGE 3	OF 7
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO. / W.O.	GROUP / EWA	ID	SEQ

1–10	11–20	21–30	31–40	41–50	51–60	61–70	71–72	77–80
DUMMY	(2X NSP CARDS FOLLOW)							
M I K	XLBAR	XMU	XKE	FPLOW	GFLEX	ITIRE		700
SI	SA	SB	SF	FSPOI	FSPOF	CDAMP		800
DUMMY	(NB CARDS FOLLOW)							
M I N J	AA	XJ	IYY	IZZ	XIQ	Z1 Z2	MC	900
DUMMY	(NMTL CARDS FOLLOW							
MC	EE	GG	STENS	SCOMP	SHEAR			1000
DUMMY	(NPIN CARDS FOLLOW)							
M I N J	PYI PZI	PYJ PZJ	SF35	SF26	SF35J	SF26J		1100
DUMMY	(NUB CARDS FOLLOW)							
M I N J	IJUB	DB						1200
DUMMY	(2X NOLEO + 1 + METERING PIN CARDS FOLLOW)							
ALPHAP	NMPTAB							1290
M I N J	EOLEO	FAO	FAA	EXPOLE	YMAX			1300
M I N J	BOLEO	BROLEO	XKEXT	XKCOMP	FCOUL	MPTAB		1400
NPTSMP			} REPEAT NMPTAB TIMES					1490
YOLEO $_i$	BOLEO $_i$	$i = 1, \ldots,$ NPTSMP	}					1500
DUMMY	(1 CARD FOLLOWS)							
DAMPC								1600
DUMMY	(ND CARDS FOLLOW)							
M I N J	CBAR							1700

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 3 OF 7)

GENERAL PURPOSE DATA SHEET

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TITLE:						PAGE	OF
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO. / W.O.	GROUP / EWA	4	7
						ID	SEQ

DUMMY	(NLB + CARDS FOLLOW)						
M I N J	L NP	LDP	LDP1				1800
XKR$_i$	KR$_i$	$i=1,\dots,NP$, REPEAT FOR ALL KR TABLES WITH $NP \geq 10$					1900
DUMMY	(1 CARD FOLLOWS IF $MVP \neq 0$)						
XN	XP	YN	YP	ZN	ZP		2000
DUMMY	(DRI SPEC. CARD(S) FOLLOW)						
I_1 J_1	I_2 J_2	-- --	I_{NDRI} J_{NDRI}				2100
DUMMY	(NVCH CARDS FOLLOW)						
I_{1i} I_{2i}	I_{3i} I_{4i}	I_{5i} I_{6i}	I_{7i} I_{8i}				2200
DUMMY	(NVBM CARDS FOLLOW)						
M I N J	VMAX1	VMAX2	VMAX3	VMAX4	VMAX5	VMAX6	2300
DUMMY	(NVBMN CARDS FOLLOW)						
M I N J	VMAXN1	VMAXN2	VMAXN3	VMAXN4	VMAXN5	VMAXN6	2400
DUMMY	(NFBM CARDS FOLLOW)						
M I N J	FMAX1	FMAX2	FMAX3	FMAX4	FMAX5	FMAX6	2500
DUMMY	(NFBMN CARDS FOLLOW)						
M I N J	FMAXN1	FMAXN2	FMAXN3	FMAXN4	FMAXN5	FMAXN6	2600

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 4 OF 7)

GENERAL PURPOSE DATA SHEET

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TITLE:						PAGE 5	OF 7
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO	GROUP		
				W.O	EWA	ID	SEQ

DUMMY (NSCV CARDS FOLLOW)
(1,1) (1,2) (1,3) (1,4) (1,5) (1,6)
— — — — — — ISCVEC(J,I) J=1,NSCV (10 MAX) I=1,6 USER INPUT SIGN CONVENTION VECTORS 2700
(NSCV,1) — — — — (NSCV,6)

DUMMY
IJ K L NLIL ISCN NSMI FSLIC(I) BLLIC(I) WLLIC(I) RUPRAT(I) 2800
FMXLIC(1,I) FMXLIC(2,I) FMXLIC(3,I) FMXLIC(4,I) 2900
(1,1,I) (2,1,I) FLIC(1,1,I) FLIC(2,1,I)
(1,2,I) (2,2,I) FLIC(1,2,I) FLIC(2,2,I) I=1,NLIC 3000
— — — — NLIL CARDS
(1,NLIL,I) (2,NLIL,I) FLIC(1,NLIL,I) FLIC(2,NLIL,I)

MXYLIC(K,J,I) K=1,2 J=1,NLIL(I) I=1,NLIC

WLSMF WLSMA 3010
IJSM1 IJSM2 IJSM3 IJSM4 IJSM5 IJSM6 IJSM7 IJSM8 IJSM9 IJSM10 IJSM11 IJSM12 IJSM13 IJSM14 3020
DUMMY (NHI CARDS FOLLOW)
I LC HEX HEY HEZ XYI YZI XZI NSY 3100
DUMMY (NPH CARDS FOLLOW)
I PHIDP THEDP PSIDP 3200
DUMMY (NAERO CARDS FOLLOW)
I CXAIR CYAIR CZAIR CLAIR CMAIR CNAIR 3300

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 5 OF 7)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

TITLE:						PAGE	OF
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP	6	7
				W.O.	EWA	ID	SEQ

```
DUMMY   (NACC + CARDS FOLLOW)
I   L   NP  NCODE                                              3400
TIME_i  ACCEL_i  i=1,...,NP; REPEAT NACC TIMES                 3500
DUMMY   (7 x NKM CARDS FOLLOW)
M I N J

K11     K12     K13     K14     K15     K16
K21     K22     K23     K24     K25     K26
K31     K32     K33     K34     K35     K36                    3600
K41     K42     K43     K44     K45     K46
K51     K52     K53     K54     K55     K56

K61     K62     K63     K64     K65     K66

DUMMY   (2 x NPLT CARDS FOLLOW)
NJTPL NMPTS ISCLE    XSCALE     YSCALE    } POSITION PLOT DATA 3700
M1  M2  M3  M4  M5  M6  M7  ---           }                    3800

DUMMY   (NMEP CARDS FOLLOW)
I   MP1  MP2  MP3  MP4  MP5  MP6  MP7  MP8  MP9                3900
DUMMY   (NNEP CARDS FOLLOW)
M   I   NP1  NP2  NP3  NP4  NP5  NP6                           4000
```

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 6 OF 7)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

TITLE:						PAGE 7	OF 7
PREPARED BY	DATE	CHECKED BY	DATE	JOB NO / W.O	GROUP / EWA	ID	SEQ

```
  DUMMY    (NBFP CARDS FOLLOW)
 IJ  BFP1  BFP2 BFP3 BFP4                          4100
  DUMMY    (NBDP CARDS FOLLOW)
 IJ  BDP1  BDP2 BDP3                               4200
  DUMMY    (NSTP CARDS FOLLOW)
 IJ  STP1  STP2 STP3 STP4 STP5                     4300
  DUMMY    (NSEP CARDS FOLLOW)
  I    M   SEP1 SEP2                               4400
  DUMMY    (NENP CARDS FOLLOW)
 IJ  ENG1  ENG2                                    4500
  DUMMY    (NDRP CARDS FOLLOW)
  J                                                4600
END                                                4700
```

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 7 OF 7)

Blank columns are treated as zeros. When the E format is used, the exponent must be right justified in the field. With the I5 integer format, the number must be right justified. The sequence numbers shown in columns 77 through 80 are only for reference purposes within this document. The actual data cards can have any numbering scheme, or no numbers at all, as long as the cards are in the proper order.

The following coordinate systems (figure 2-4) are established to facilitate the derivation of equations for the mathematical model. The input data description specifies the appropriate coordinate systems to be used.

- Ground Coordinate System. - This is a right-handed coordinate system fixed in the ground with the origin at point O in figure 2-4. The x-axis is positive forward, the y-axis is positive to the right, and the z-axis is positive downward. The xy-plane (z = 0) corresponds to the ground surface. The ground coordinate system is considered an inertial coordinate system for writing the dynamic equations of motion.

- Slope Coordinate System. - This is a right-handed coordinate system fixed in the ground with the origin at point O as shown in figure 2-4. The x-axis is positive forward up the slope, the y-axis is positive to the right, and the z-axis is positive downward and perpendicular to the slope. This coordinate system is the same as the ground coordinate system rotated through an angle 'beta', positive clockwise about the ground y-axis. The xy-plane represents a plane inclined at an angle 'beta' with respect to the horizontal ground plane. 'Beta' is a constant input angle that can range from zero to ninety degrees.

- Airplane Coordinate System. - This is a left-handed coordinate system fixed with relation to the airplane with the origin at point H in figure 2-4. The x-axis is positive aft, the y-axis is positive to the left when looking forward, and the z-axis is positive upward. The origin at point H corresponds to zero fuselage station (FS = 0), zero buttline (BL = 0), and zero waterline (WL = 0). This coordinate system is used only to input the location coordinates of the mass points and massless node points since the coordinates of the points are usually available in terms of fuselage station, buttline, and waterline.

- Center-of-Gravity Coordinate System. - This is a right-handed coordinate system fixed with relation to the airplane with the origin at the vehicle c.g., point G. The x-axis is positive forward, the y-axis is positive to the right when looking forward, and the z-axis is positive downward. These axes are parallel to the airplane coordinate system axes.

- Mass Point Coordinate System. - Each mass point has its own right-handed coordinate system fixed with relation to the mass point. The initial orientation of each of these coordinate systems is arbitrary and is specified by means of three input Euler angles for each mass point relating its initial orientation to the center-of-gravity coordinate system since the inertia data are generally available about these axes and the three input Euler angles are zero. The mass point coordinate system is the system used to write Euler's equations of motion for each mass point.

- Beam Element Coordinate System. - This is a right-handed coordinate system with the beam element x-axis along a straight line from the mass point at end 'I' to the mass point at end "j". As the mass points move, the beam element coordinate system changes orientation so that the x-axis is always pointing from the mass point at end 'I' to the mass point at end 'J'. If the beam element connects massless node points which are offset from the mass points, then the beam element x-axis always points from the massless node point rigidly attached to the mass point at end 'I' to the massless node point rigidly attached to the mass point at end 'J'.

  The beam element y-axis and z-axis are mutually perpendicular. The direction of each is arbitrary and is defined internally within the program. The input data are prepared according to the beam element coordinate systems shown in figure 2-5 (page 2-46).

The following is a detailed description of all the input data requirements.

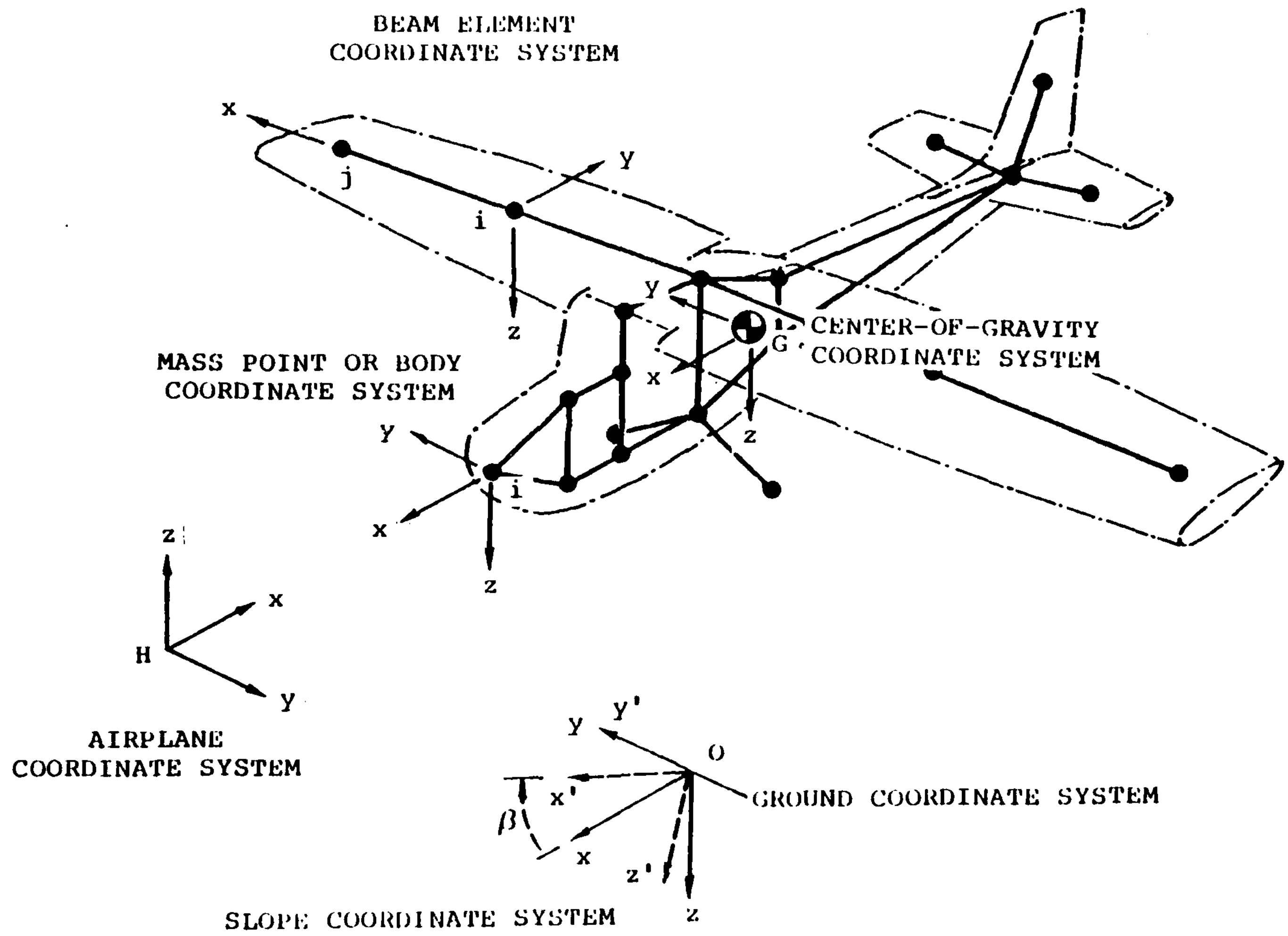


FIGURE 2-4. KRASH85 COORDINATE SYSTEMS

KRASH* INPUT DATA

CARD 0010: TITLE CARD #1

DESCRIPTION: Defines an alphanumeric label which will appear as the first line of heading on each page of KRASH* printed output.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

TITLE1	
SUBSTRUCTURE SECTION IMPACT STUDY	0010

FIELD	CONTENTS
Title1	Alphanumeric Character String

REMARKS: (1) Required data card; however, it may be blank.
(2) All text material on this card is reproduced at the top of every output page and on every plot.

CARD 0020: TITLE CARD #2

DESCRIPTION: Defines an alphanumeric label which will appear as the second line of heading on each page of KRASH printed output.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

TITLE2	
INITIAL CONDITIONS: 27.5 FPS VERTICAL IMPACT ON RIGID SURFACE	0020

FIELD	CONTENTS
Title2	Alphanumeric Character String

REMARKS: (1) Required data card; however, it may be blank.
(2) All text material on this card is reproduced at the top of every output page and on every plot.

*KRASH refers to KRASH85 in all subsequent input data sheets

KRASH INPUT DATA

CARD 0030: DUMMY CARD

DESCRIPTION: Defines a numeric heading which will appear on each page of the KRASH printout of the input data deck echo.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
DUMMY	
123456789012345678901234567890123456789012345678901234567890123456789012	0030

FIELD	CONTENTS
Dummy	Numeric String

REMARKS: (1) Required data card; however, it may be blank.
(2) Intent of this data card is to aid the user in verifying the field placement of the input data.

CARD 0040: KRASH MODEL SIZE PARAMETERS

DESCRIPTION: Defines the sizes of the various input parameter data sets for the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

NM	NSP	NB	NLB	NNP	NPIN	NUB	NDRI	NOLEO	NACC	MVP	NVCH	NMTL	ND	X	
16	10	32	2	6	0	4	0	0	0	0	0	0	1		0040

FIELD	CONTENTS
NM	Number of Mass Points Per 0200-Series Cards (Maximum Allowed is 80)
NSP	Number of External Crushing Springs Per 0700/0800-Series Cards (Maximum Allowed is 40)
NB	Number of Beam Elements Per 0900-Series Cards (Maximum Allowed is 150)
NLB	Number of Beam Element Nonlinear Degrees-of-Freedom Per 1800-Series Cards (Maximum Allowed is 180)
NNP	Number of Massless Node Points Per 0300-Series Cards (Maximum Allowed is 50)
NPIN	Number of Beam Elements Having at Least One Degree-of-Freedom Pinned Per 1100-Series Cards (Maximum Allowed is 150)
NUB	Number of Axially Unsymmetric Beam Elements Per 1200-Series Cards (Maximum Allowed is 150)
NDRI	Number of DRI Beam Elements Per 2100-Series Cards (Maximum Allowed is 150)
NOLEO	Number of Shock Strut Elements Per 1300 and 1400-Series Cards (Maximum Allowed is 20)
NACC	Number of Enforced Acceleration Time History Tables Per 3400/3500-Series Cards (Maximum Allowed is 100 Input Tables, With a Total of 5000 Time Points)
MVP	Reference Mass Point For Volume Penetration Calculations Per 2000-Series Cards (Maximum Allowed is 1)
NVCH	Number of Volumes For Occupiable Volume Change Calculations Per 2200-Series Cards (Maximum Allowed is 5)
NMTL	Number of Non-Standard Beam Element Materials Per 1000-Series Cards (Maximum Allowed is 10)
ND	Number of Beam Elements With Non-Standard Damping Ratios Per 1700-Series Cards (Maximum Allowed is 150)

REMARKS:
(1) Required data card.
(2) All entries are right justified integers.
(3) 'NM' and 'NB' must be nonzero.
(4) Blank entries are read as zero.
(5) See Table 2-1 for a summary of model size parameters.
(6) Format for this card is 14I5.

TABLE 2-2. PROGRAM SIZING CONSTANTS

CONSTANT	MAXIMUM VALUE	DESCRIPTION
NM	80	NUMBER OF MASSES
NSP	40	NUMBER OF EXTERNAL SPRINGS
NB	150	NUMBER OF INTERNAL BEAMS
NLB	180	NUMBER OF NONLINEAR BEAM-DIRECTION COMBINATIONS (KR TABLES)
NHI	80	NUMBER OF MASSES HAVING NON-ZERO He_{x_i}, He_{y_i}, He_{z_i}, I_{xy_i}, I_{yz_i}, I_{xz_i}, OR ℓc_i
MVP	-	REFERENCE MASS NUMBER FOR VOLUME PENETRATION CALCULATIONS
NVCH	5	NUMBER OF VOLUMES FOR OCCUPIABLE VOLUME CHANGE CALCULATIONS
NDRI	150	NUMBER OF DRI BEAM ELEMENTS
NMTL	10	NUMBER OF NON-STANDARD BEAM MATERIALS
NACC	100	NUMBER OF INPUT ACCELERATION TIME-HISTORY TABLES (TOTAL NUMBER OF TIME POINTS = 5000)
NVBM	150	NUMBER OF INTERNAL BEAMS HAVING NON-STANDARD MAXIMUM POSITIVE (NVBM) OR NEGATIVE (NVBMN)
NVBMN	150	DEFLECTIONS FOR BEAM RUPTURE. STANDARD VALUE = 100 (inches OF DEFLECTION AND radians OF ROTATION)
NFBM	150	NUMBER OF INTERNAL BEAMS HAVING NON-STANDARD MAXIMUM POSITIVE (NFBM) OR NEGATIVE (NFBMN)
NFBMN	150	FORCES FOR BEAM RUPTURE. STANDARD VALUE = 1E10
NPH	80	NUMBER OF MASSES HAVING NON-ZERO EULER ANGLES ϕ_i'', θ_i'', ψ_i''
ND	150	NUMBER OF INTERNAL BEAMS HAVING DAMPING RATIOS DIFFERENT FROM THAT SPECIFIED ON CARD 1600
NKM	150	NUMBER OF INTERNAL BEAMS FOR WHICH THE FULL 6 x 6 STIFFNESS MATRIX IS DIRECTLY INPUT
NPIN	150	NUMBER OF INTERNAL BEAMS HAVING OTHER THAN FIXED-FIXED END CONDITIONS
NNP	50	NUMBER OF MASSLESS NODE POINTS
NUB	150	NUMBER OF UNSYMMETRICAL BEAMS
NOLEO	20	NUMBER OF SHOCK STRUTS

CARD 0050: KRASH MODEL SIZE PARAMETERS AND CALCULATION FLAGS

DESCRIPTION: Defines the sizes of the various input parameter data sets for the KRASH model and provides for beam element stress and/or failure data calculations.

FORMAT AND EXAMPLE:

NVBM	NFBM	NVBMN	NFBMN	NKM	NHI	NPH	NTOL1	NTOL2	NTOL3	NSC	NIC	NAERO	NBOMB	X		
0	0	0	0	0	0	0	10	50	100	0	0					0050

(Card columns: 0 1 2 3 4 5 6 7 8 — 1234567890123456789012345678901234567890123456789012345678901234567890123456789 0)

FIELD CONTENTS

NVBM Number of Beam Elements Having Non-Standard Rupture Positive Deflections Per 2300-Series Cards (Maximum Allowed is 150)

NFBM Number of Beam Elements Having Non-Standard Rupture Positive Forces Per 2500-Series Card (Maximum Allowed is 150)

NVBMN Number of Beam Elements Having Non-Standard Rupture Negative Deflections Per 2400-Series Card (Maximum Allowed is 150)

NFBMN Number of Beam Elements Having Non-Standard Rupture Negative Forces Per 2600-Series Cards (Maximum Allowed is 150)

NKM Number of Beam Elements For Which 6 x 6 Stiffness Matrix is Directly Input Per 3600 Series Cards (Maximum Allowed is 150)

NHI Number of Mass Points Having Nonzero Aerodynamic Lift Constant, Angular Momenta, or Cross Products of Inertia Per 3100-Series Card (Maximum Allowed is 80)

NPH Number of Mass Points Having Nonzero Euler Angles For Rotating the Mass Point or Body Coordinate System Relative to The Center-of-Gravity Coordinate System Per 3200-Series Cards (Maximum Allowed is 80)

NTOL1 Percent Allowable Total Energy Growth Above 100 Percent (Default Value is One (1) Percent)

NTOL2 Percent Allowable Individual Negative Strain, Damping, Crushing and Friction Terms of Respective Totals (Default Value is Ten (10) Percent)

NTOL3 Percent Allowable Individual Mass Energy Deviation Above Zero Percent (Default Value is Thirty (30) Percent

NSC Flag For Beam Element Stress Calculation: 0 = No 1 = Yes

NIC Flag For Preliminary Beam Element Failure Load and Deflection Calculations: 0 = No 1 = Yes

NAERO Number of Masses Having Aerodynamic Data Input Per 3300-Series Card (Maximum Allowed is 80)

NBOMB Any Nonzero Input Will Override all Energy Growth Error Checks. Run Will Execute to Completion Regardless of Energy Calculations.

REMARKS:

(1) Required data card; however it may be blank.
(2) All entries are right justified integers.
(3) Blank entries are read as zero.
(4) If any of the allowable errors in energy are exceeded, the analysis terminates automatically at that time, and summary tables and printer plots are generated.
(5) Default values for NVBM and NVBMN are 100 inches or radians. Default values for NFBM and NFBMN are 1E10, lbs or in-lbs.
(6) See Table 2-1 for a summary of model size parameters.
(7) It is recommended that NIC = 1 be used each time if complete beam properties are input (0900-series cards).
(8) Format for this card is 14I5.

CARD 0060: KRASH MODEL SIZE AND PROGRAM CONTROL PARAMETERS

DESCRIPTION: Defines the sizes of input parameter data sets for the KRASH model and controls the output of graphics information and specifies the type of initial conditions to be used.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
NSCV	NLIC	NWRGRA	NBAL	ICD	ICITER			
1	16	0	5	1	1			0060

FIELD CONTENTS

NSCV — Number of User-Specified Sign Convention Vectors, Per 2700-Series Cards, To Be Used in Conjunction With Load-Interaction Curve Data. (Maximum Allowed is 10) NSCV May be Zero.

NLIC — Number of Load-Interaction Curves Per 2800/3000-Series Cards (Maximum Allowed is 40)

NWRGRA — Parameter Which Governs Whether Graphics Data For Postprocessing is Written to The User's Data File. NWRGRA = 0 Results in No Data Being Written to The User's File. Any Nonzero Input Will Result in Mass and Node Point Displacement Time-History Data, Plus Load-Interaction Time-History Data (if NLIC $\neq$ 0), being written to the user's data file, in data set DSC, Defined in JCL.

NBAL — If MSC/NASTRAN is To Be Used For a Static Solution, Then NBAL is The Mass Number That is Constrained to Have Zero Deflections and Rotations.

ICD — Parameter Which Determines Whether an Additional Data Set of Mass and Node Point Static Deflections is To Be Read Following the Basic Input Data Set. ICD = 0 Means That The Additional Data Set is Not Read. Any Nonzero Input Causes The Program to Read The Initial Deflection Data.

ICITER — Parameter Which Determines Whether The Initial Mass and Node Point Deflection Data (ICD $\neq$ 0) is Used To Modify The Input Airplane Coordinates For The Mass and Node Points. ICITER = 0 Means The Initial Static Deflection Data is Not Used to Modify The Mass Coordinates; i.e., The Airplane is Left in Its Undeformed Position. Any Nonzero Value of ICITER Results in The Input Mass Coordinates Being Modified to Reflect The Initial Static Deflections, i.e., The Airplane Assumes The Deformed Shape Corresponding to The Initial Static Load Condition.

REMARKS:

(1) Required data card; however, it may be blank.
(2) All entries are right justified integers.
(3) See Section 3.1 for a discussion of the load-interaction curve data; Section 2.1 for a discussion of initial conditions.
(4) Format for this card is 6I5.

CARD 0070: ACCELERATION TRANSFER CONTROL PARAMETERS

DESCRIPTION: Defines number of time-history tables of mass accelerations to be used.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890						
(CSIN)	X	(RNIN)	X	NTAB		
				3		0070

FIELD	CONTENTS
(CSIN)	Not Used
(RNIN)	Not Used
NTAB	Number of Acceleration Time-History Tables to Be Used From Previous Run, Using Data Set Identified as DSA in JCL. Maximum Allowed is 100.

REMARKS:

(1) Required data card; however, it may be blank.
(2) NTAB is input as a right justified integer.
(3) See Section 3.2 for a discussion of acceleration transfer procedures.
(4) Format for this card is (A6, 4X, A10, 5X, I5).

CARD 0080: ACCELERATION TRANSFER CONTROL PARAMETERS

DESCRIPTION: Defines data for saving mass and mode point accelerations for later use as input data in another run.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
(CSOUT.	(RNOUT)	NMSAV	NNPSAV	NDTSAV	NWRFLG	NDTGRA		
		6	3	10	1	20		0080

FIELD	CONTENTS
(CSOUT)	Not Used
(RNOUT)	Not Used
NMSAV	Number of Masses For Which Selected Acceleration Data Will be Saved in Data Set DSB (Identified in JCL), as Specified on 500-Series Cards (Maximum allowed is 80) See Remark (5).
NNPSAV	Number of Node Points For Which Selected Acceleration Data Will be Saved in Data Set DSB (Identified in JCL), as Specified on 600-Series Cards (Maximum Allowed is 50) See Remark (5)
NDTSAV	Multiple of Integration Time Interval DT at Which Acceleration Data Will be Saved. See Remark (4)
NWRFLG	Parameter Governing Whether Selected Acceleration Data Will be written to User's Data File as Data Set DSB. Any Nonzero Value Will Cause The Data to be Written: NWRFLG = 0 Will Cause The Data Not to be Written. Regardless of The Remaining Input Parameters on This Card.
NDTGRA	Multiple of Integration Time Interval DT at Which Mass and Node Point Displacement Data Will be Written to User's Data File as Data Set DSC (Identified in JCL). This Data is Used For Graphics Postprocessing. NWRGRA on Card 0600 Must be Nonzero For This Data to be Written as DSC in User's Data File. NDTGRA Also Defines The Time Interval For Saving Load-Interaction Data. For The Load Interaction Data, if NWRGRA on Card 0060 is Zero, The Print Output Will Still Contain Time-Histories of All Load Interaction Output Data. If it is Desired to Save This Data in Data Set DSC For Postprocessing, Then NWRGRA Must be Input Nonzero. See Remark (4).

REMARKS:

(1) Required data card; however, it may be blank.

(2) All entries are right justified integers.

(3) See Sections 3.1 and 3.2 for discussions of load-interaction curve data and acceleration transfer control and graphics data.

(4) Both NDTSAV and NDTGRA must be chosen so that less than 100 time cuts are saved for each response quantity. This is satisfied if

$$\left(\begin{array}{c}\text{NDTSAV}\\ \text{and}\\ \text{NDTGRA}\end{array}\right) > \frac{\text{TMAX}}{100 * \text{DT}}$$

(5) The total number of response quantities saved (total number of nonzero MFL's and NPFL's on 0500 and 0600 Series Cards) must be less than 100.

(6) Format for this card is (A6, 4X, A10, 5I10).

CARD 0090: RESTART CONTROL PARAMETERS

DESCRIPTION: Defines the identifiers of a previously checkpointed KRASH case and the simulation time from which the KRASH analysis will be restarted.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

CASEIN		RUNIN	MSECIN						
OLEO		1	40						0090

FIELD CONTENTS

FIELD	CONTENTS
CASEIN	Alphanumeric Identifier of Checkpointed Case (Maximum of Eight Characters, Left Justified)
RUNIN	Numeric Identifier of Checkpointed Case
MSECIN	Restart Time – Milliseconds

REMARKS:

(1) Required data card, however, it may be blank.
(2) All numeric entries are right justified integers.
(3) Previously checkpointed case must be resident on mag tape and be accessed via JCL.
(4) Restart time must be included in the KRASH analysis of the previously checkpointed case.
(5) Only nonblank when using restart capability to initiate from a preceding analysis that has been saved.
(6) Format for this card is(A8, 2X, 6I10).

KRASH INPUT DATA

CARD 0100: CHECKPOINT CONTROL PARAMETERS

DESCRIPTION: Defines indentifiers and simulation times for the current KRASH case to checkpoint the analytical results for future restarts.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

CASEOUT	X	RUNOUT	MSCOUT(1)	MSCOUT(2)	MSCOUT(3)	MSCOUT(4)	MSCOUT (5)	X	
OLEO		2	40	80	100	120	150		0100

FIELD	CONTENTS
CASEOUT	Alphanumeric Identifier (Maximum of Eight Characters, Left Justified)
RUNOUT	Numeric Identifier
MSCOUT1	Analysis Times at Which Results Will be Saved – Milliseconds

REMARKS:

(1) Required data card; however, it may be blank.
(2) All numeric entries are right justified integers.
(3) JCL must provide mag tape on which results will be saved.
(4) Only nonblank when data are to be saved. A maximum of five times can be saved per analysis.
(5) Format for this card is (A8, 2X, 6I10.0).

KRASH INPUT DATA

CARD 0110: PARAMETERS FOR NUMERICAL INTEGRATION, PLOWING FORCE, ACCELERATION FILTER, AND KRASH EXECUTION MODE

DESCRIPTION: Defines print control, numerical integration time step, analysis time, plowing force time, acceleration filter cutoff frequency, and KRASH execution mode (airplane model and impact condition symmetry).

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

DP/DT	DT	TMAX	PLOWT	FCUT	RUNMOD			
100	0.00001	0.120	0.0	100.0	1.0			0110

FIELD	CONTENTS
DP/DT	Multiple of Numerical Integration Time Interval at Which Output Will be Printed, Right Justified Interger
DT	Fixed Time Step For Numerical Integration – Seconds
TMAX	Maximum Analysis Time – Seconds
PLOWT	Analysis Time at Which Plowing Forces Cease – Seconds
FCUT	Cutoff Frequency of First-Order Filter Applied to Mass Point Translational Accelerations – Hertz (E10.0 Format)
RUNMOD	Flag to Control the Mode of Program Execution as Follows:

RUNMOD	INPUT DATA SET	DATA SET ANALYZED	AIRPLANE MODEL	IMPACT CONDITIONS
0.	Full Airplane	Full Airplane	Unsymmetrical	Unsymmetrical
1.	Half Airplane	Half Airplane	Symmetrical	Symmetrical
2.*	Half Airplane	Full Airplane	Symmetrical	Unsymmetrical

*See remark (5)

REMARKS:

(1) Required data card.
(2) 'DP/DT', 'DT', 'TMAX', and 'RUNMOD' are required inputs.
(3) Blank entries are read as zero.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) For RUNMOD = 2, image mass number = 100 + mass number.
(6) Suitable values for 'DT' range from 0.00001 to 0.001 seconds. A rule of thumb for selecting a final integration value is the following:
    DT ≤ 0.01 Max. Computed Beam Frequency (Hz).
(7) Nonzero plowing forces act from time = 0 to time = 'PLOWT'. For time > 'PLOWT' the plowing forces are set to zero.
(8) Suitable values for 'FCUT' range from fifty to eighty-five percent of the actual test filter cutoff frequency. Eighty-five percent is commonly used.
(9) Format for this card is (I10, 5E10.0).

CARD 0120: VARIABLE INTEGRATION PARAMETERS

DESCRIPTION: Define parameters for numerical integration with variable time step.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8
IVAR	EL	EU	RATMIN	RATMAX				
1	0.01	0.10	0.6	2.0				0120

FIELD CONTENTS

IVAR Flag For Type of Numerical Integration With Variable Time Step as Follows (Right Justified Integer):

IVAR	TYPE OF NUMERICAL INTEGRATION WITH VARIABLE TIME STEP
0	None
1	Tolerance Based on Six Linear and Angular Velocities of Each Mass Point
2	Tolerance Based on Energy

EL Maximum Tolerance
EU Minimum Tolerance
RATMIN Integration Time Step Factor if Tolerance > 'EU'
RATMAX Integration Time Step Factor if Tolerance < 'EL'

REMARKS:
(1) Required data card, but it should be blank as the variable integration algorithm is not currently operational.
(2) Blank entries are read as zero.
(3) Format for this card is (I10, 4E10.0).

CARD 0130: PRINT OUTPUT CONTROL

DESCRIPTION: Defines flags to control the printout of results, KRASH model size parameters, and allowable errors in energy for terminating the analysis.

FORMAT AND EXAMPLE:

NSF	NTF	NDE	NSPD	NED	NS	NRP	NIMP	NBC					
1	1	1	1	1	1	1	1	1					0130

FIELD	CONTENTS
NSF	Flag For Printout of Beam Element Strain Forces
NTF	Flag For Printout of Beam Element Total Forces – Strain and Damping
NDE	Flag For Printout of Beam Element Deflections
NSPD	Flag For Printout of External Crushing Spring Loads and Deflections
NED	Flag For Printout of Energy Distribution Per Mass Point, Beam Element, and External Crushing Spring
NS	Flag For Printout of Beam Element Stresses
NRP	Flag For Printout of Mass Point Displacement, Velocity, and Accelerations
NIMP	Flag For Printout of Mass Impulses
NBC	Flag For Printout of Beam Component Loads

REMARKS:
(1) Required data card; however, it may be blank.
(2) All entries are right justified integers.
(3) Blank entries are read as zero.
(4) Print control flags: 0 = No, 1 = Yes.
(5) At time zero or the first time cut of a restart, all print will be output regardless of the entries on this card.
(6) Format for this card is 8I5.

CARD 0140: PRINTER PLOT CONTROL PARAMETERS

DESCRIPTION: Defines the type and number of time history printer plots and defines the number of mass point position (structure deformation) printer plots.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

NMEP	NNEP	NBFP	NBDP	NSTP	NSEP	NENP	NDRP	NPLT	NPFCT				
21	0	3	0	0	0	2	1	2	20				0140

FIELD	CONTENTS
NMEP	Number of Mass Points Having Time History Printer Plots Per 3900-Series Cards
NNEP	Number of Massless Node Points Having Time History Printer Plots Per 4000-Series Cards
NBFP	Number of Beam Elements Having Load Time History Printer Plots Per 4100-Series Cards
NBDP	Number of Beam Elements Having Deflection Time History Printer Plots Per 4200-Series Cards
NSTP	Number of Beam Elements Having Stress Time History Printer Plots Per 4300-Series Cards
NSEP	Number of External Crushing Springs Having Time History Printer Plots Per 4400-Series Cards
NENP	Number of Beam Elements Having Strain and/or Damping Energy Time History Printer Plots Per 4500-Series Cards
NDRP	Number of DRI Mass Points Having Time History Printer Plots Per 4600-Series Cards
NPLT	Number of Mass Point Position (Structure Deformation) Printer Plots Per 3700/3800-Series Cards
NPFCT	Print Time Factor For Which Mass Point Position (Structure Deformation) Plots Are Generated

REMARKS:
(1) Required data card; however, it may be blank.
(2) All entries are right justified integers.
(3) Blank entries are read as zero.
(4) Blank or zero entries do not generate printer plots.
(5) Mass position plots occur at time = 0, and at intervals equal to NPFCT x DP DT x DT.
(6) Format for this card is 10I5.

KRASH INPUT DATA

CARD 0150: INITIAL AIRPLANE LINEAR VELOCITIES

DESCRIPTION: Defines the initial airplane linear velocity components with respect to the ground coordinate system.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7		8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	
XGDOT	YGDOT	ZGDOT						
0.0	0.0	360.0						0150

FIELD CONTENTS

XGDOT Initial Fore-and-Aft Velocity of Airplane, Positive Forward
YGDOT Initial Lateral Velocity of Airplane, Positive Right
ZGDOT Initial Vertical Velocity of Airplane, Positive Down

REMARKS:
(1) Required data cards; however, it may be blank.
(2) Velocity units are inches per second.
(3) Blank entries are read as zero.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Format for this card is 3E10.0.

CARD 0160: INITIAL AIRPLANE ANGULAR VELOCITIES

DESCRIPTION: Defines the initial airplane angular velocity components with respect to the ground coordinate system.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890		8
PPR	QPR	RPR	X	X	X	X	X		
0.0	0.0	0.012							0160

FIELD	CONTENTS
PPR	Initial Airplane Roll Velocity, Positive Right Wing Down
QPR	Initial Airplane Pitch Velocity, Positive Nose Up
RPR	Initial Airplane Yaw Velocity, Positive Nose Right

REMARKS:
(1) Required data card; however, it may be blank.
(2) Angular velocity units are radians per second.
(3) Blank entries are read as zero.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Format for this card is 3E10.0.

CARD 0170. MISCELLANEOUS AIRPLANE INITIAL CONDITIONS

DESCRIPTION: Defines the initial airplane attitude Euler angles and the initial airplane linear position with respect to the ground coordinate system and defines the ground plane slope angle.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

PHIPR	THEPR	PSIPR	XGIN	ZGIN	BETA	RHO	X	
0.0	0.001	0.0	0.0	0.0	45.0	1.1463E-07		0170

FIELD	CONTENTS
PHIPR	Initial Airplane Roll Euler Angle, Positive Right Wind Down – Radians
THEPR	Initial Airplane Pitch Euler Angle, Positive Nose Up – Radians
PSIPR	Initial Airplane Yaw Euler Angle, Positive Nose Right – Radians
XGIN	Fore-and-Aft Distance of Airplane Initial CG Position Relative to the Basic Position Calculated in the Initial Condition Subroutine, Positive Aft – Inches
ZGIN	Vertical Distance of Airplane Initial CG Position Relative to the Basic Position Calculated in the Initial Condition Subroutine, Positive Up – Inches
BETA	Ground Plane Slope Angle, Positive Up – Degrees
RHO	Air Density Used for Calculating Aerodynamic Loads (NAERO $\neq 0$), Pound-Sec^2/In^4

REMARKS:

(1) Required data card; however, it may be blank.
(2) Blank entries are read as zero.
(3) Normally, 'XGIN' and 'ZGIN' are input as zero and the KRASH initial conditions subroutine positions the airplane relative to ground.
(4) If it is desired to have the airplane impact only on the slope and not on the horizontal ground, a large value of ZGIN may be input (1000 inches). This will move the airplane upward ZGIN above the horizontal ground, and simultaneously move it forward so that it is almost contacting the slope. The normal initial position for the airplane is wedged into the juncture of the horizontal ground and the slope as explained in Volume I, Section 1.3.15
(5) Values of 'BETA' range from zero to ninety degrees (horizontal to vertical impact surfaces).
(6) Entries requiring scientific notation (X.XEXX) should be right justified.
(7) If NSP = 0 (no external springs), ZGIN is the distance from the ground plane to the airplane CG, positive up.
(8) Formats for this card is 7E10.0.

CARDS 0200: MASS POINT DATA

DESCRIPTION: Defines the weight, location coordinates, and mass moments of inertia for each of the mass points in the KRASH model.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	12345678	90
WGT	XDP	YDP	ZDP	XI	YI	ZI	ID	
103.0	50 0	20.0	33.0	12.5	3.7	12.5	21	0200

FIELD	CONTENTS
WGT	Weight – Pounds
XDP	Fuselage Station Coordinate, Positive Aft – Inches
YDP	Buttline Coordinate, Positive Left – Inches
ZDP	Waterline Coordinate, Positive Up – Inches
XI	Roll Mass Moment of Inertia – Inch * Pound * Second**2
YI	Pitch Mass Moment of Inertia – Inch * Pound * Second**2
ZI	Yaw Mass Moment of Inertia – Inch * Pound * Second**2
ID	Mass Point Number

REMARKS:

(1) 'NM' on card 0040 specifies the number of these cards for input.
(2) The order of these cards determines the mass point number.
(3) Blank entries are read as zero.
(4) The location coordinates are defined in a left-handed coordinate system.
(5) At least one of the three mass moments of inertia must be nonzero.
(6) Mass moment of inertia cross products may be defined on the 3100-series of cards.
(7) Entries requiring scientific notation (X.XEXX) should be right justified.
(8) Mass point number (ID) must be greater than zero or less than 100. Mass numbers must be unique and can be input in any order. If ID for any mass point is left blank, all mass points will automatically be numbered sequentially in the order of input.
(9) For RUNMOD = 2, the Image mass point number will equal the mass point number plus 100.
(10) Formats for this card is 7E10.0, I2.

CARDS 0300: MASSLESS NODE POINT DATA

DESCRIPTION: Defines for each of the massless node points in the KRASH model the location coordinates and the mass point number to which each is rigidly attached.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7		8
12345	67890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890		1234567890
MNP	INP	XNPDP	YNPDP	ZNPDP					
1	12	10.0	-12.0	33.0					0300

FIELD	CONTENTS
MNP	Massless Node Point Number (Right Justified Integer)
INP	Mass Point Number (Right Justified Integer)
XNPDP	Fuselage Station Coordinate, Positive Aft – Inches
YNPDP	Buttline Coordinate, Positive Left – Inches
ZNPDP	Waterline Coordinate, Positive Up – Inches

REMARKS:

(1) Optional data card(s).
(2) 'NNP' on card 0040 specifies the number of these cards for input.
(3) 'MNP' and 'INP' must be nonzero.
(4) Blank entries are read as zero.
(5) The massless node point number is determined by taking each mass point and numbering the node points attached to it 1, 2, 3, . . . etc. There is no limit on the number of node points that may be connected to a single mass point.
(6) The location coordinates are defined in a left-handed coordinate system.
(7) User should not place a node point on the center line for a RUNMOD = 2 condition. Program will not generate a connection across this point. User can place node point slightly off center, if necessary.
(8) Generally used to model regions wherein rigid connections exist (i.e., seat, engine) or where multiple behavior is being represented by different elements.
(9) Entries requiring scientific notation (X.XEXX) must be right justified.
(10) Format for this card is (2I5, 3E10.0).

CARDS 0400: ACCELERATION TRANSFER DATA

DESCRIPTION: Defines the correspondence between mass/node point numbers from a previous model for which acceleration data was saved, and the current model which is to use the acceleration data as input forcing functions.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

ISNEW	(MSNEW)	LSNEW	ISOLD	MSOLD	LSOLD	TSH		
3		4	6	3	4	.003		**0400**

FIELD	CONTENTS
ISNEW	Mass Number in Current (New) Model That Will be Driven by an Acceleration Table Saved in Data Set DSA (defined in JCL)
(MSNEW)	Not Used (Coding Does Not Allow Driving a Node Point With an Input Acceleration)
LSNEW	Direction for Which Table Read From Data Set DSA Will Drive Mass ISNEW

LSNEW: 1 = XACCEL 4 = PDOT
2 = YACCEL 5 = QDOT
3 = ZACCEL 6 = RDOT

ISOLD	Mass Number in Previous (OLD) Model, The Acceleration From Which Will be Used to Drive Mass ISNEW in The Current Model
MSOLD	Node Point Number in Previous (OLD) Model. Coding Allows Driving a Mass in The Current Model With an Acceleration From a Node Point in The Previous Model
LSOLD	Direction of Acceleration Saved in Prior Model to be Used to Drive the Current Model. It is Not Necessary for LSOLD = LSNEW; i.e., an XACCEL From a Previous Model Can Drive a ZACCEL in The Current Model

LSOLD: 1 = XACCEL 4 = PDOT 7 = XACC FILTERED
2 = YACCEL 5 = QDOT 8 = YACC FILTERED
3 = ZACCEL 6 = RDOT 9 = ZACC FILTERED

TSH: Time Shift Applied to Data From Previous Model (Stored in DSA) Before Using in Current Model. This Allows User to Apply a "Downstream" Response From Previous Model as Input to The Current Model, Which Starts at t = 0

$$t_{NEW} = t_{OLD} - TSH$$

REMARKS:
(1) Optional data card(s).
(2) NTAB on card 0070 specifies the number of these cards for input.
(3) Data set DSA, generated from a previous run, must be in the user's data file in order to use the acceleration transfer data. The actual data set name for DSA is specified in the JCL.
(4) A different TSH can be specified for each table used.
(5) Filtered accelerations from a previous model can be used to drive the current model. (LSOLD = 7, 8 or 9).
(6) Format for this card is (6I5, IE10.0).

CARDS 0500: MASS ACCELERATION SAVE PARAMETERS

DESCRIPTION: Defines mass numbers and directions for saving acceleration time-history data.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890											
	ISAV	MFL1	MFL2	MFL3	MFL4	MFL5	MFL6	MFL7	MFL8	MFL9		
	15	0	0	1	0	1	1	0	1	0		**0500**

FIELD	CONTENTS
ISAV	Mass Number For Which Acceleration Data From Current Run Will be Stored in User's Data File in Data Set DSB
MFL1 - MFL9	Flags Defining For Which Directions (1-9) Acceleration Date is to be Saved in Data Set DSB. Input Either 1 or 0 for Each Item; 1 Denotes Save The Acceleration Time-History For The Indicated Direction. Directions 1-9 Correspond to The Description of LSOLD on Cards 0400.

REMARKS:

(1) Optional data card(s).
(2) NMSAV on Card 0080 specifies the number of these cards for input.
(3) Date set DSB is specified in the JCL.
(4) The acceleration data is saved at time intervals of NDTSAV, specified on Card 80.
(5) NWRFLG on Card 80 must be nonzero to write the acceleration data into date set DSB.
(6) Format for this card is (5X, 10I5).

CARDS 0600: NODE POINT ACCELERATION SAVE PARAMETERS

DESCRIPTION: Defines node point numbers and directions for saving acceleration time-history data.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890

MNPSAV	INPSAV	NPFL1	NPFL2	NPFL3	NPFL4	NPFL5	NPFL6	NPFL7	NPFL8	NPFL9			
3	15	0	0	1	0	1	1	0	1	0			0600

FIELD CONTENTS

ISAV, MNPSAV — Mass and Node Point Number for Which Acceleration Data From Current Run Will be Stored in User's Data File in Data Set DSB

NPFL1 NPFL9 — Flags Defining for Which Directions (1-9) Acceleration Date is to be Saved in Data Set DSB. Input Either 1 or 0 for Each Item; 1 Denotes Save The Acceleration Time-History for The Indicated Direction. Directions 1-9 Correspond to The Description of LSOLD on Cards 0400.

REMARKS:

(1) Optional data card(s).
(2) NNPSAV on Card 0080 specifies the number of these cards for input.
(3) Date set DSB is specified in the JCL.
(4) The acceleration data are saved at time intervals of NDTSAV, specified on Card 80.
(5) NWRFLG on Card 80 must be nonzero to write the acceleration data into date set DSB.
(6) Format for this card is 11I5.

CARDS 0700: EXTERNAL CRUSHING SPRING PARAMETERS

DESCRIPTION: Defines the attach point, direction, length, ground coefficient of friction, bottoming spring rate, plowing force, and ground flexibility for each of the external crushing springs in the KRASH model.

FORMAT AND EXAMPLE:

0 1234567890 ... 8 (card columns)											
M	I	K	XLBAR	XMU	XKE	FPLOW	GFLEX	ITIRE			
	11	3	10.0	0.3	20000.0	0.0	0.0	1			0700

FIELD	CONTENTS
M	Massless Node Point Number (Right Justified Integer)
I	Mass Point Number (Right Justified Integer)
K	Degree-of-Freedom in Which External Crushing Spring Acts Where 1, 2, 3 Correspond to the X, Y, Z Directions in the Mass Point Coordinate System (Right Justified Integer)
XLBAR	Free Length of Spring Either Positive or Negative in the Mass Point Coordinate System - Inches
XMU	Impact Surface Coefficient of Friction. Values of Between 0.35 to 0.60 are Appropriate For Structure to Ground Contact.
XKE	Bottoming Spring Rate – Pounds Per Inch
FPLOW	Plowing Force -- Pounds
GFLEX	Impact Surface Flexibility – Inches Per Pound
ITIRE	Defines spring that remains normal to contact surface

REMARKS:

(1) Optional data card(s).

(2) 'NSP' on card 0040 specifies the number of these cards for input.

(3) Blank entries are read as zero.

(4) The free length of the external crushing spring is arbitrary; however, the value generally represents the actual depth of the crushable structure.

(5) A value of zero for the impact surface flexibility (GFLEX) represents a rigid surface. A flexibility value of 0.00036 in/lb is an approximate representation in KRASH for soil. having a CBR $\approx$4 and moisture content of $\approx$30 percent.

(6) Entries requiring scientific notation (X.XEXX) must be right justified.

(7) If ITIRE = 1 external spring remains normal to contact surface. Use only for tire representation in K = 3 direction. If Beta > 0 tire spring remains normal to sloped surface. Not coded to account for transition from flat to sloped surface.

(8) Format for this card is (I2, I3, I5, 5E10.0, I5).

CARDS 0800: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION AND DAMPING PARAMETERS

DESCRIPTION: Defines four deflection points, two load values and one damping value for each external crushing spring in the KRASH model.

FORMAT AND EXAMPLE:

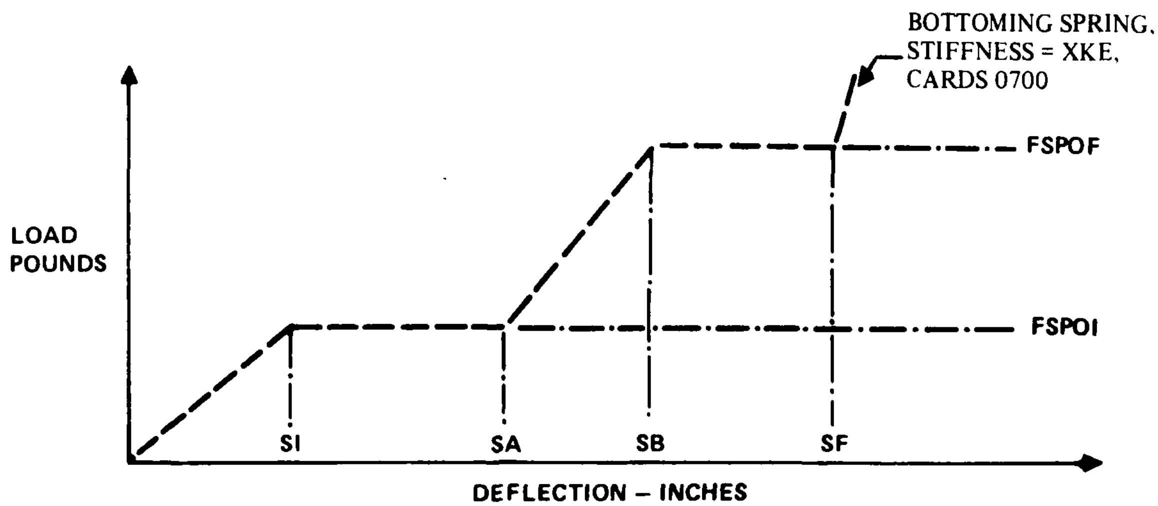
0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

SI	SA	SB	SF	FSPOI	FSPDF	CDAMP	X	
0.1	1.0	3.5	5.0	10000.0	25000.0	.08		0800

FIELD	CONTENTS
SI	Deflection Point at Which First Linear Region Ends and First Nonlinear Region Begins – Inches
SA	Deflection Point at Which First Nonlinear Region Ends and Second Linear Region Begins – Inches
SB	Deflection Point at Which Second Linear Region Ends and Second Nonlinear Region Begins – Inches
SF	Deflection Point at Which Second Nonlinear Region Ends and Linear Bottoming Begins – Inches
FSPOI	Constant Load Between Deflection Points SI and SA – Pounds
FSPOF	Constant Load Between Deflection Points SB and SF – Pounds
CDAMP	Critical Damping Ratio. Acceptable Range is .02 to .10

REMARKS:

(1) 'NSP' on card 0040 specifies the number of these cards for input.
(2) These load-deflection cards must be ordered to correspond with the 0700-series cards of external crushing spring data.
(3) The general shape of the load-deflection curve is as follows:



CARDS 0800: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION AND DAMPING PARAMETERS (Continued)

(4) External spring damping in program KRASH is computed as:

$$2 * \text{CDAMP} * \sqrt{(\text{FSPOI/SI}) * \text{WGT} / 386.4}$$

where WGT is the weight for mass i.

(5) Entries requiring scientific notation (X.XEXX) should be right justified.
(6) Format for this card is 7E10.0.

CARDS 0900: BEAM ELEMENT PROPERTIES

DESCRIPTION: Defines the end points and cross-sectional properties for each beam element in the KRASH model.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890

M	I	N	J	AA	XJ	IYY	IZZ	XIQ	Z1	Z2	MC	
	2	1	5	0.5	0.0	3.67	1.54	0.0	0.0	0.0	4	900

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number at End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
AA	Cross-Sectional Area – Inches**2.
XJ	Torsional Stiffness Inertia – Inches**4
IYY	Cross-Sectional Area Moment of Inertia About Beam Element Y-Axis For Bending In X-Z Plane – Inches**4
IZZ	Cross-Sectional Area Moment Of Inertia About Beam Element Z-Axis For Bending In X-Y Plane – Inches**4
XIQ	Cross-Sectional Shape Factor Relating Torsional Shear Stress To The Applied Moment – 1/Inches**3
Z1	Distance From The Neutral Axis To The Extreme Fibers In The Beam Element Z-Direction – Inches
Z2	Distance From The Neutral Axis To The Extreme Fibers In The Beam Element Y-Direction – Inches
MC	Material Code Number (Right Justified Integer)

REMARKS:

(1) "NB" on card 0040 specifies the number of these cards for input.
(2) Blank entries are read as zero.
(3) At least one beam element must be defined.
(4) The order of these data cards determines the beam element number.
(5) If "XJ" is input as zero, KRASH will automatically compute a value for "XJ" as the sum of "IYY" and "IZZ".
(6) The beam element coordinate system depends on the geometric orientation as shown in Figure 2-5.
(7) "XIQ", "Z1", and "Z2" are used only for stress calculations (See Section 1.3.17 in Volume I).
(8) The torsional stress parameter "XIQ" is equal to the shape factor "1/Q" used in Roark's formulas for stress and strain (Reference 4).
(9) KRASH has ten standard materials internally defined as shown in Table 2-2.
(10) Entries requiring scientific notation (X.XEXX) should be right justified.
(11) Format for this card is (2(I2, I3), 5E10.0, 2F5.0, I2).

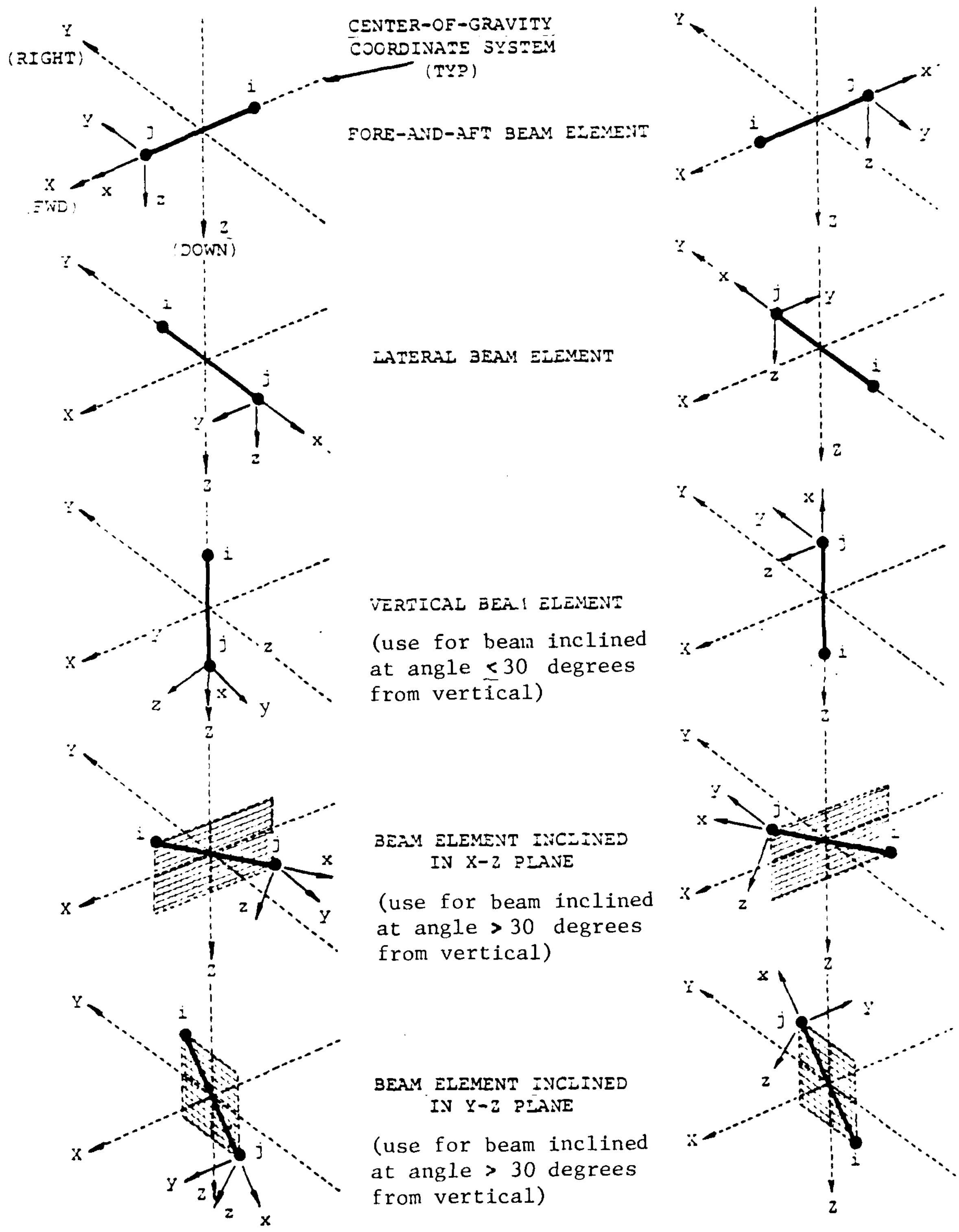


FIGURE 2-5. BEAM ELEMENT COORDINATE SYSTEM ORIENTATIONS

TABLE 2-3. STANDARD MATERIAL PROPERTIES

MC	MATERIAL	MODULUS OF ELASTICITY (PSI)	MODULUS OF RIGIDITY (PSI)	TENSILE STRESS (PSI)	COMPRESSIVE STRESS (PSI)	SHEAR STRESS (PSI)
1	4130 STEEL	30.0E6	11.0E6	75000	75000	37500
2	6150H STEEL	30.0E6	11.0E6	205000	205000	80000
3	300-SERIES STAINLESS STEEL	28.0E6	12.5E6	70000	46000	36000
4	2024 T3 ALUMINUM	10.5E6	4.0E6	47000	39000	22000
5	6061-T3 ALUMINUM	10.0E6	3.8E6	35000	34000	17000
6	8195-T4 CAST ALUMINUM	10.0E6	3.8E6	16000	16000	17000
7	LOW MODULUS MATERIAL	1.0E6	0.4E6	16000	16000	17000
8	ZERO TORSION MATERIAL	1.0E6	0.0	16000	16000	17000
9	DRI SPINE (MAN)	1.0E6	0.4E6	16000	16000	17000
10	DRI SPINE (DRI)	1.0E6	0.4E6	16000	16000	17000

KRASH INPUT DATA

CARDS 1000: NON-STANDARD MATERIAL PROPERTIES

DESCRIPTION: Defines non-standard material properties for beam elements in the KRASH model.

FORMAT AND EXAMPLE.

0 1234567890		2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890		8 1234567890
MC		EE	GG	STENS	SCOMP	SHEAR			
11		10.3E06	3.9E06	35000.0	34000.0	17000.0			1000

FIELD	CONTENTS
MC	Material Code Number. MC = 11-20 (Right Justified Integer)
EE	Modulus Of Elasticity – Pounds Per Inch**2
GG	Modulus Of Rigidity – Pounds Per Inch**2
STENS	Tensile Yield Stress – Pounds Per Inch**2
SCUMP	Compressive Yield Stress – Pounds Per Inch**2
SHEAR	Shear Stress – Pounds Per Inch**2

REMARKS

(1) Optional data card(s).
(2) "NMTL" on card 0040 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) The yield stress properties are required when stress calculations are desired.
(5) The standard materials available in KRASH are listed in Table 2-2.
(6) Entries requiring scientific notation (X.XEXX) should be right justified.
(7) Format for this card is (I5, 5X, 5E10.0).

CARDS 1100: BEAM ELEMENT PINNED END CONDITIONS

DESCRIPTION: Defines the end points and the degrees-of-freedom for the beam elements with pinned end conditions in the KRASH model.

FORMAT AND EXAMPLE:

0 1234567890			1 1234567890		2 1234567890		3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
M	I	N	J	PYI	PZI	PYJ	PZJ	SF35	SF26	SF35J	SF26J	
	2	6	0	0	1	0	1.0	1.5	1.2		1.0	1100

FIELD	CONTENTS
M	Massless Node Point Number At End "I"
I	Mass Point Number At End "I"
N	Massless Node Point Number At End "J"
J	Mass Point Number At End "J"
PYI	Pin Flag For Bending Moment About Beam Element Y-Axis At End "I"
PZI	Pin Flag For Bending Moment About Beam Element Z-Axis At End "I"
PYJ	Pin Flag For Bending Moment About Beam Element Y-Axis At End "J"
PZJ	Pin Flag For Bending Moment About Beam Element Z-Axis At End "J"
SF35	Beam Shape Factor At End "I" About Beam Y-Axis
SF26	Beam Shape Factor At End "I", About Beam Z-Axis
SF35J	Beam Shape Factor At End "J" About Beam Y-Axis
SF26J	Beam Shape Factor At End "J" About Beam Z-Axis

REMARKS:

(1) Optional data card(s).
(2) "NPIN" on card 0040 specifies the number of these cards for input.
(3) The pin flags are defined as follows:
0 = Fixed
1 = Pinned
(4) Blank entries are read as zero.
(5) All entries except SF26, SF35, SF26J and SF35J are right justified integers. SF26, SF35, SF26J and SF35J are E10.0 format.
(6) The beam element Y- and Z-axis directions depend on the beam element geometric orientation as shown in Figure 2-3.
(7) Bending moments about the beam element Y- and Z-axes correspond to bending moments in the beam element X-Z and X-Y planes, respectively, as outlined in Table 2-3.
(8) All entries requiring scientific notation (X.XEXX) should be right justified.
(9) Format for this card is (2 (I2, I3), 4I5, 4E10.0).
(10) Beam shape factors SF26 and SF35, SF26J, and SF35J can be obtained from Table 2-4. and Reference 14.
(11) SF26, and/or SF35 values are required for representation of plastic hinge at beam end I.
(12) SF26J and/or SF35J values are required for representation of plastic hinge at beam end J.

NOTE: The end fixity card is used:

(a) to pin one or both ends of a beam

If a beam end is to be pinned then the desired PY, PZ, PYJ and PZJ flags are used and the SF26, SF35, SF26J and SF35J values are input as zero. The program will treat these beams as not providing for moments at the appropiiate end and direction.

(b) to define a beam that can develop a plastic hinge at one or both ends of the beam.

If a plastic hinge is represented the appropriate beam end direction (PY, PZ, PYJ, PZJ) must be flagged and a corresponding (SF35, SF26, SF35J, SF26J) must have a value. The program will treat such a beam as fixed until such time as the plastic moment is formed. Thereafter the beam moment in the noted direction is maintained (no longer changes). In order to use the plastic moment equations the user must have beam section properties Z1 or Z2 (card 0900) defined since KRASH computes the plastic moment as follows:

$$M_p = f\left(\frac{\sigma_y I}{y_{max}}\right)$$

where

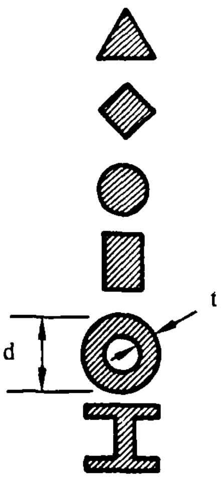
f	=	shape factor (SF35, SF26, SF35J, SF26J)
σ_y	=	material yield stress (contained in the material code table), lb/in^2
I	=	area moment of inertia, either I_{yy} or I_{zz}, in^4
y_{max}	=	distance to neutral axis either Z1 or Z2, in

The following table shows the relationship between directional moments and appropriate input terms for program KRASH.

TABLE 2-4. RELATIONSHIP FOR DIRECTIONAL MOMENTS AND INPUT TERMS IN KRASH

FORCE ALONG AXIS	MOMENT ABOUT AXIS	FORCE, MOMENT DESIGNATION	KRASH DIRECTION NUMBERS	APPROPRIATE INPUT REQUIREMENT: AREA MOMENT OF INERTIA (CARD 0900)	DISTANCE FROM N.A. TO ELEMENT EXTREME FIBER (CARD 0900)	SHAPE FACTOR "i" END	SHAPE FACTOR "j" END	PIN CODING "i" END	PIN CODING "j" END
z	y	F_z, M_θ	3, 5	IYY	Z1	SF35	SF35J	PY	PYJ
y	z	F_y, M_ψ	2, 6	IZZ	Z2	SF26	SF26J	PZ	PZJ

TABLE 2-5. SHAPE FACTORS FOR PLASTIC HINGE BEAMS (Reference 14)



SHAPE	SHAPE FACTOR, f (SF35, SF26, SF35J, SF26J) IN PROGRAM KRASH
Triangle	2.37
Diamond	2.0
Circle	1.7
Rectangle	1.5
Tube	1.40 t/d = 10 1.27 t = 0
I-beam	1.15 Ranges 1.10 to 1.22

0 $f = Z/S$

$Z = 2 H_e$

$S = I/Y_{max}$

where:

- I = Section area moment of inertia
- Y_{max} = Distance from neutral axis to extreme fiber
- H_e = Static moment of half the cross section with respect to the neutral axis
- Z = Plastic modulus
- S = Elastic section modulus
- f = Shape factor

CARDS 1200: AXIALLY UNSYMETRIC BEAM ELEMENT PARAMETERS

DESCRIPTION: Defines end points, type of load, and deadband for the beam elements with unsymetrical axial properties in the KRASH model.

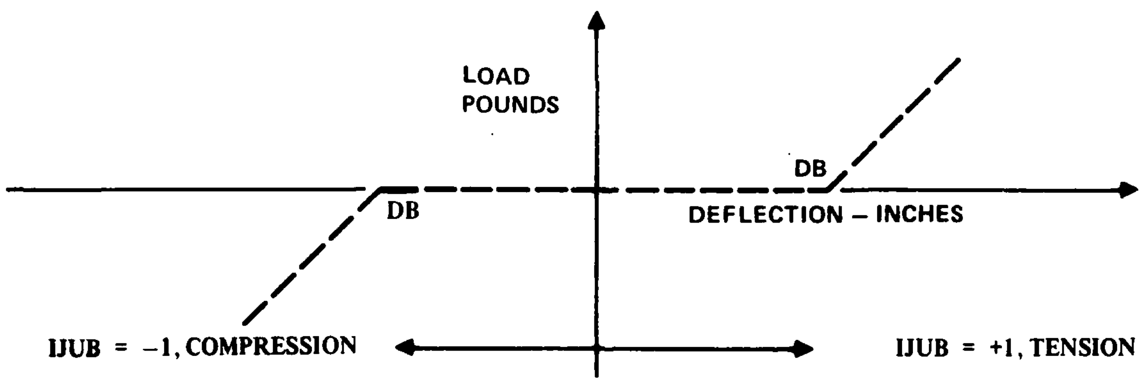
FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	IJUB	☒	DB	☒	☒	☒	☒	☒	
	2	1	5	−1		1.5						1200

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
IJUB	Flag For The Type Of Axial Loading In The Beam Elements IJUB = +1, Tension Only IJUB = -1, Compression Only
DB	Deadband for axial loading, inches

REMARKS
(1) Optional data card(s).
(2) "NUB" on card 0040 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) The general form of the load-deflection curve for the axially unsymetric beam element is as follows:



(5) This type of beam element may also incorporate nonlinear characteristics by specifying the nonlinear properties per the 1800-series cards.
(6) The axial load-deflection curves that can be obtained using this capability are described in Volume I, Section 1.3.5.3.5. (Reference 1)
(7) Format for this card is (2 (I2, I3), I5, 5X, E 10.0).

CARD 1290: SHOCK STRUT DATA

DESCRIPTION: Friction coefficient and number of metering pin tables.

FORMAT EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890								
ALPHAP	NMPTAB							
1.0	2							1290

FIELD CONTENTS

ALPHAP Constant For Use In Computing Shock Strut Friction Force
NMPTAB Number of Separate Metering Pin Tables Input on Cards 1490/1500.

REMARKS:

(1) Optional data card.
(2) Required only if NOLEO ≠ 0 (card 0040)
(3) Only 1 card regardless of NOLEO value
(4) Blank entry read as zero
(5) Range of ALPHAP is between .1 to 2.0. The smaller the alphap used the closer the representation is to pure Coulomb friction. Generally a value of 1.0 is suitable.
(6) See Appendix A for the discussion on oleo friction forces for alphap selection.
(7) Format for this card is (E10.0, I10).

KRASH INPUT DATA

CARDS 1300: SHOCK STRUT DATA

DESCRIPTION: Air curve parameters

FORMAT EXAMPLE:

M	I	N	J	EOLEO	FAO	FAA	EXPOLE	YMAX			
	1		7	10.27	116.	5.	1.0	9.32			1300

Card columns 1–80: 0 1 2 3 4 5 6 7 8

FIELD	CONTENTS
M	Massless Node Point Number In End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
EOLEO	Effective Total Strut Cylinder Length, in.
FAO	Fully Extended Gear Preload, lb.
FAA	Ambient Air Preload, lb.
EXPOLE	Polytropic Exponent.
YMAX	Maximum Stroke, in.

REMARKS:

(1) Optional data cards.
(2) "NOLEO" on card 0040 specifies the number of these cards for input.
(3) All entries requiring scientific notation (X.XEXX) should be right justified.
(4) EXPOLE ranges from 1 (isothermal) to 1.4 (adiabatic). Adiabatic condition will usually prevail.
(5) See Appendix A for a description of the shock strut parameters and their usage.
(6) Format for this card is (2 (I2, I3), 5E10.0).

KRASH INPUT DATA

CARDS 1400: SHOCK STRUT DATA

DESCRIPTION: Damping constants, linear springs at extended and compressed ends of strut travel and coulomb friction.

FORMAT EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	BOLEO	BROLEO	XKEXT	XKCOMP	FCOUL	MPTAB	X	
	1		7	0.24	0.48	10000.	10000.	5.5	1		1400

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
BOLEO	Strut Orifice Damping lb-sec ^{2}/in ^{2}
BROLEO	Strut Rebound Valve Damping lb-sec ^{2}/in ^{2}
XKEXT	Linear Spring At Extended End Of Strut Travel, lb/in.
XKCOMP	Linear Spring At Compressed End Of Strut Travel, lb/in.
FCOUL	Coulomb Or Constant Friction Force, lbs.
MPTAB	Metering Pin Table Number. If a Metering Pin Is Not Used, Input Zero. MPTAB Refers to Metering Pin Tables Input Sequentially On 1500-Series Cards.

REMARKS:

(1) Optional data cards.
(2) "NOLEO" on card 0040 specifies the number of these cards for input.
(3) All entries requiring scientific notation (X.XEXX) should be right justified.
(4) See Appendix A for a description of the shock strut parameters and their usage.
(5) If a metering pin table is used, BOLEO is ignored. If MPTAB is input as a negative integer, the subsequent table on cards 1500 is interpreted as total gear load versus stroke. This is used only for the inverse metering pin option, explained in Appendix A.
(6) No. of cards = NPTSMP value (card 1290)
(7) Format for this card is (2(I2, I3), 5E10.0, I10).

CARD 1490: METERING PIN DATA

DESCRIPTION: Number of points in following metering pin table

FORMAT EXAMPLE:

0 1 2 3 4 5 6 7 8		
12345678901234567890123456789012345678901234567890123456789012345678901234567890		
NPTSMP		
15		**1490**

FIELD CONTENTS

NPTSMP Number of Cards in The Following Table of YOLEO Versus BOLEO (Maximum Allowable is 100)

REMARKS:
(1) Optional data card. Required only if MPTAB is nonzero on any of the 1400-Series cards.
(2) This card precedes each 1500-Series of metering pin table cards. For example, if there were 3 metering pin tables (NMPTAB = 3 on card 1290), the proper sequence would be

1490	1 card
1500-XX	$NPTSMP_1$ cards
1490	1 card
1500-XX	$NPTSMP_2$ cards
1490	1 card
1500-XX	$NPTSMP_3$ cards

(3) Format for this card is I10

CARDS 1500: METERING PIN DATA

DESCRIPTION: Table(s) of oleo piston compression versus damping constant.

FORMAT EXAMPLE

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890			
YOLEO	BOLEO		
7.	1.76E02		**1500**

FIELD	CONTENTS
YOLEO	Oleo Piston Compression, Inches, Measured From Fully Extended Position
BOLEO	Oleo Hydraulic Damping Constant, Pount-Sec ^{2}/in^2, at The Piston Position Defined by YOLEO

REMARKS

(1) Optional data card(s). NPTSMP on card 1490 defines the number of these cards to input. If NMPTAB = 0 on card 1290, then none of these cards are used.

(2) Format for this card is 2E10.0.

(3) If MPTAB on card 1400 is input as a negative integer, then BOLEO on the corresponding 1500-Series cards is interpreted as total gear load. This is referred to as the inverse metering pin option, which can be used to calculate BOLEO versus YOLEO if a known (or desired) load-deflection characteristic curve is input on this series of cards. This option is explained in Appendix A.

CARD 1600: BEAM ELEMENT DAMPING RATIO

DESCRIPTION: Defines an overall damping ratio for the beam elements in the KRASH model.

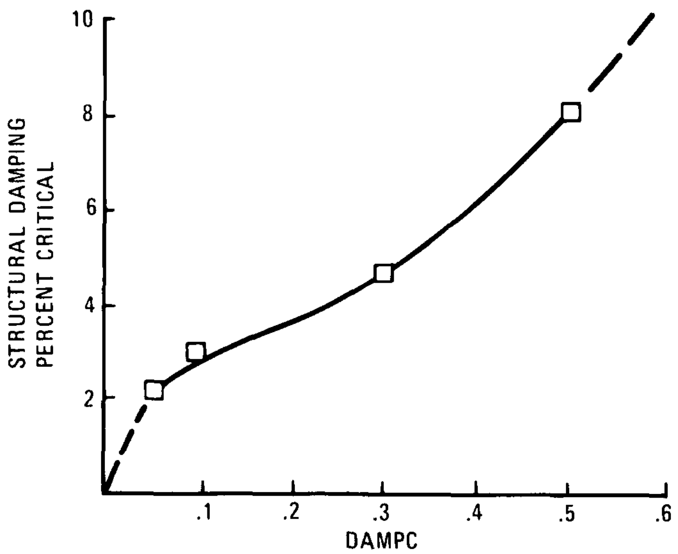
FORMAT AND EXAMPLE

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8
DAMPC								
0.10								1600

FIELD CONTENTS

DAMPC Damping Ratio (Actual/Critical)

REMARKS:
(1) Required data card; however, it may be blank.
(2) Blank entry is read as zero damping for all beams.
(3) DAMPC values in KRASH are between .1 and .5. The sketch below shows the relationship between DAMPC values and percent of critical damping.
(4) Format for this card is E10.0



CARDS 1700: NON-STANDARD BEAM ELEMENT DAMPING RATIOS

DESCRIPTION: Defines the end points and damping ratio for each beam element in the KRASH model for which a non-standard damping ratio is required.

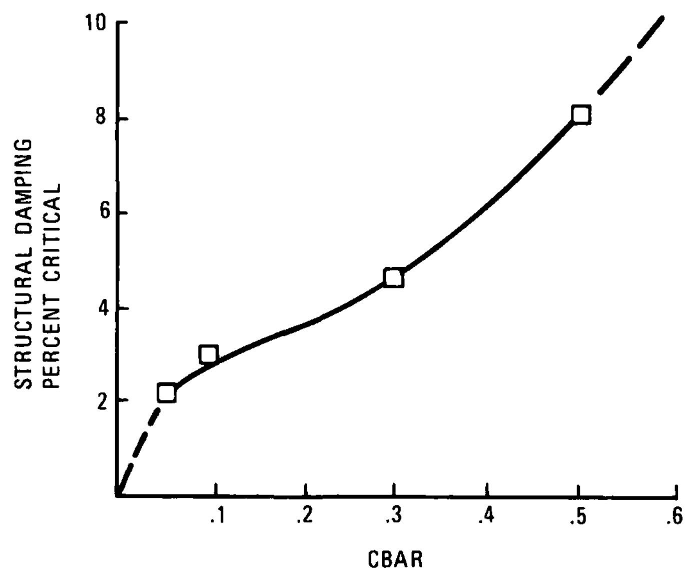
FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	CBAR							
	2	1	5	0.10							**1700**

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
CBAR	Damping Ratio (Actual/Critical)

REMARKS:
(1) Optional data card(s).
(2) "ND" on card 0040 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) CBAR values in KRASH are between .1 and .5. The sketch below shows the relationship between CBAR values and percent critical damping.
(5) Format for this card is (2 (12, 13), E10.0).



KRASH INPUT DATA

CARDS 1800: NONLINEAR BEAM ELEMENT PARAMETERS

DESCRIPTION: Defines the end points, degree-of-freedom, KR table type, and linear deflection points for the nonlinear beam elements in the KRASH model.

FORMAT AND EXAMPLE:

M	I	N	J	L	NP	LDP	LDP1					
	2	1	5	3	7	1.5	0.0					1800

(Card columns: 0 1 2 3 4 5 6 7 8 / 1234567890123456789012345678901234567890123456789012345678901234567890123456789 0)

FIELD	CONTENTS
M	Massless Node Point Number At End "1" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
L	Nonlinear Degree-Of-Freedom Where L = 1, 2, 3, 4, 5, 6 Corresponds To The Beam Element Coordinate System Directions X, Y, Z, ϕ, θ, ψ. Respectively (Right Justified Integer)
NP	Number Of Data Points Used In KR Table (Right Justified Integer)
LDP	Deflection At Which Nonlinear Behavior Begins – Inches
LDP1	Deflection At Which Nonlinear Behavior Ends And Linear Restiffening Begins – Inches except as noted in remark (8).

REMARKS:

(1) Optional data card(s).

(2) "NLB" on card 0040 specifies the number of these cards for input.

(3) Blank entries are read as zero.

(4) The nonlinear degrees-of-freedom are specified in the beam element coordinate systems shown in figure 2-3.

(5) For "NP" = 4-9 the corresponding standard KR tables are shown in figure 2.6. For "NP" >9 the user will input a nonstandard KR table with "NP" data points.

(6) "LDP1" is used for the KR table "NP" = 9 and for "NP" = 4 (see remark 8).

(7) The theory on how the KR curves are used to calculate internal beam loads is shown in Volume I, Section 1.3.5.3.4. (Reference 1).

(8) For "NP" = 4 the LDP value represents the deflection value at which KR = 1. (LINEAR). LDP1 represents KR value (< 1). 0 $\leq$ deflection $\leq$ LDP. NP = 4 can be useful for modeling elements such as a seat cushion which is soft initially and stiffens during compression. Do not use with LDP1 > 1.0

(9) Format for this card is (2 (I2, I3) 2I5, 2E10.0).

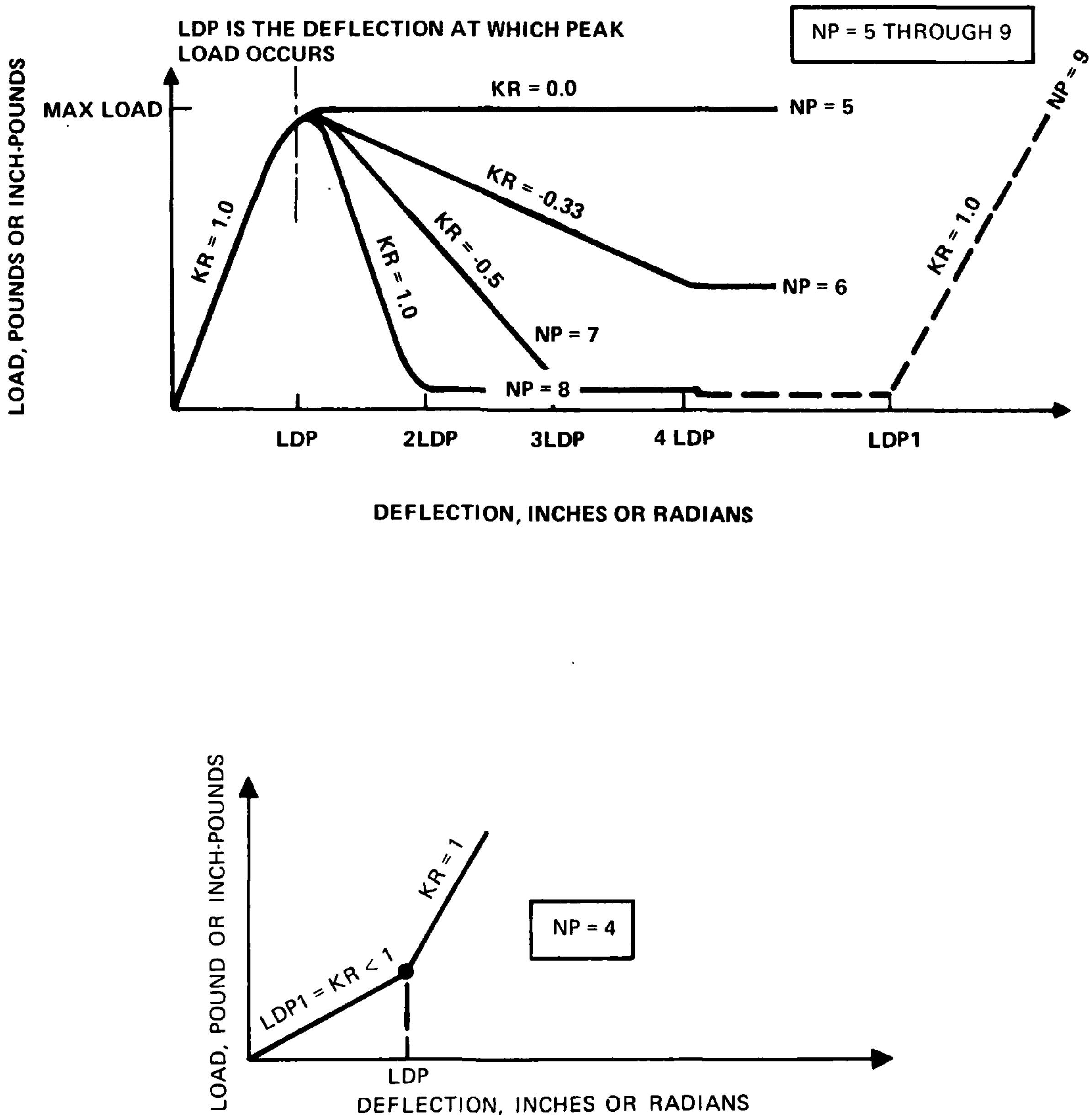


FIGURE 2-6. STANDARD NONLINEAR BEAM ELEMENT STIFFNESS REDUCTION CURVES

KRASH INPUT DATA

CARDS 1900: NON-STANDARD KR TABLE DATA POINTS

DESCRIPTION: Defines non-standard KR tables for the nonlinear beam elements in the KRASH model which cannot be described with the standard KR tables.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

XKR	KR							
1.0	−1.0							1900

FIELD	CONTENTS
XKR	Deflection - Inches
KR	Stiffness Reduction Factor at XKR

REMARKS:
(1) Optional data cards.
(2) For each use of "NP" > 9 on the 1200-series cards, "NP" of these cards are required input.
(3) Blank entries are read as zero.
(4) Within each set of "NP" data cards, deflections must be in ascending order.
(5) Each set of "NP" data cards must be ordered to correspond with the 1800 - series cards where "NP" > 9 is used.
(6) Format for this card is 2E10.0.

CARD 2000: CONTROL VOLUME MASS PENETRATION PARAMETERS

DESCRIPTION: Defines a control volume around a selected mass point in the KRASH model which is monitored for penetration by another mass point during the analysis.

FORMAT AND EXAMPLE

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1	7 234567890 / 8
XN	XP	YN	YP	ZN	ZP			
10.0	10.0	3.0	4.0	10.5	2.9			2000

FIELD CONTENTS

FIELD	CONTENTS
XN	Distance From Mass Point To Aft Side Of Control Volume
XP	Distance From Mass Point To Forward Side Of Control Volume
YN	Distance From Mass Point To Left Side Of Control Volume
YP	Distance From Mass Point To Right Side Of Control Volume
ZN	Distance From Mass Point To Top Side Of Control Volume
ZP	Distance From Mass Point To Bottom Side Of Control Volume

REMARKS:

(1) Optional data card.
(2) 'MVP" on card 0040 specifies the mass point number for which this data card applies.
(3) Only one mass point may have a control volume.
(4) Blank entries are read as zero.
(5) All distances are positive and units are inches.
(6) For a RUNMOD = 2 the MVP mass should be selected from a mass point located on the airplane centerline. This restriction doesn't apply to RUNMOD = 0 or 1.
(7) Any of the model mass points may penetrate the designated control volume of the model.
(8) The mass penetration calculations are described in Volume I, Section 1.3.10.
(9) Format for this card is 6E10.0.

CARD 2100: DRI ELEMENT SPECIFICATION

DESCRIPTION: Defines the end mass points of the DRI beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0	1		2		3		4		5		6		7		8
1234567890	1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		1234567890		
I1	J1	I2	J2	I3	J3	I4	J4	I5	J5	I6	J6	I7	J7	X	
3	10														2100

FIELD CONTENTS

II Mass Point Number At End "I"
JI Mass Point Number At End "J"

REMARKS:
(1) Optional data card(s).
(2) "NDRI" on card 0040 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) Blank entries are read as zero.
(5) Up to seven DRI beam elements can be specified on each card. (Normally an analysis requires from 1 to 4 DRI elements).
(6) DRI beam element section properties can be defined on the 0900-series cards or if a MTL code of 10 is used the program will automatically compute the DRI properties.
(7) Beams that connect massless node points cannot be used as DRI elements, only direct mass to mass connection is allowed.
(8) The usage of DRI elements is described in Volume I, Section 1.3.12.
(9) Format for this card is 14I5.

KRASH INPUT DATA

CARD 2200: OCCUPIABLE VOLUME CHANGE PARAMETERS

DESCRIPTION: Defines occupiable volumes in the KRASH model for volume change calculations by specifying the eight corner mass points.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I1	I2	I3	I4	I5	I6	I7	I8					
3	7	12	13	21	23	31	35					2200

FIELD	CONTENTS
I1	Mass Point Number At Forward End, Upper Left-Hand Corner
I2	Mass Point Number At Forward End, Upper Right-Hand Corner
I3	Mass Point Number At Aft End, Upper Left-Hand Corner
I4	Mass Point Number At Aft End, Upper Right-Hand Corner
I5	Mass Point Number At Forward End, Lower Left-Hand Corner
I6	Mass Point Number At Forward End, Lower Right-Hand Corner
I7	Mass Point Number At Aft End, Lower Left-Hand Corner
I8	Mass Point Number At Aft End, Lower Right-Hand Corner

REMARKS:

(1) Optional data card(s).
(2) "NVCH" on card 0004 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) Blank entries are not allowed.
(5) The volume change calculations are explained in Volume I, Section 1.3.11 (Figure 1-16).
(6) For a symmetrical full model (RUNMOD = 2 type) when only half the data is input the user inputs mass point locations 1, 3, 5, 7 (I1, I3, I5, I7). The opposite side mass point locations 2, 4, 6, 8 (I2, I4, I6, I8) are input as zero (blank). KRASH automatically computes the opposite side masses. See Volume I. Figure 1-16 for mass point designations.
(7) Format for this card is 8I5.

CARDS 2300: NON-STANDARD MAXIMUM BEAM ELEMENT POSITIVE DEFLECTIONS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum positive deflections and rotations for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	VMAX1	VMAX2	VMAX3	VMAX4	VMAX5	VMAX6	X	
	2	1	6	10.0	15.2	100.0	100.0	0.2			2300

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
VMAX1	Maximum Deflection In Beam Element X-Direction – Inches
VMAX2	Maximum Deflection In Beam Element Y-Direction – Inches
VMAX3	Maximum Deflection In Beam Element Z-Direction – Inches
VMAX4	Maximum Rotation About Beam Element X-Axis – Radians
VMAX5	Maximum Rotation About Beam Element Y-Axis – Radians
VMAX6	Maximum Rotation About Beam Element Z-Axis – Radians

REMARKS:

(1) Optional data card(s).
(2) "NVBM" on card 0050 specifies the number of these cards for input.
(3) The standard or default values for maximum deflections and rotations are 100 inches and 100 radians, respectively. The deflections and rotations refer to relative motions of the j end of the beam minus the i end of the beam.
(4) The beam element coordinate systems are shown in Figure 2-5.
(5) All values are input as positive numbers.
(6) Format for this card is (2 (I2, I3), 6E10.0).

CARDS 2400:

NON-STANDARD MAXIMUM BEAM ELEMENT NEGATIVE DEFLECTIONS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum negative deflections and rotations for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0 1234567890			1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 12345678	8 90
M	I	N	J	VMAXN1	VMAXN2	VMAXN3	VMAXN4	VMAXN5	VMAXN6		
	2	1	6	10.0	15.2	100.0	100.0	0.2	100.0		2400

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
VMAXN1	Maximum Deflection In Beam Element X-Direction – Inches
VMAXN2	Maximum Deflection In Beam Element Y-Direction – Inches
VMAXN3	Maximum Deflection In Beam Element Z-Direction – Inches
VMAXN4	Maximum Rotation About Beam Element X-Axis – Radians
VMAXN5	Maximum Rotation About Beam Element Y-Axis – Radians
VMAXN6	Maximum Rotation About Beam Element Z-Axis – Radians

REMARKS:

(1) Optional data card(s).
(2) "NVBMN" on card 0050 specifies the number of these cards for input.
(3) The standard or default values for maximum deflections and rotations are 100 inches and 100 radians, respectively. The deflections and rotations refer to relative motions of the j end of the beam minus the i end of the beam.
(4) The beam element coordinate systems are shown in Figure 2-5.
(5) All values are input as positive numbers.
(6) Format for this card is (2 (I2, I3), 6E10.0).

CARDS 2500: NONSTANDARD MAXIMUM BEAM ELEMENT POSITIVE LOADS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum forces and moments for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0				1	2	3	4	5	6	7	8
12345678901234567890123456789012345678901234567890123456789012345678901234567890											
M	I	N	J	FMAX1	FMAX2	FMAX3	FMAX4	FMAX5	FMAX6	X	
	3		7	10.0E10	1000.0	10.0E10	10.0E10	10.0E6	10.0E10		2500

FIELD	CONTENTS
M	Massless Node Point Number at End "I" (Right Justified Integer)
I	Mass Point Number at End "I" (Right Justified Integer)
N	Massless Node Point Number at End "J" (Right Justified Integer)
J	Mass point Number at End "J" (Right Justified Integer)
FMAX1	Maximum Axial Force in Beam Element X-Direction - Pounds
FMAX2	Maximum Shear Force in Beam Element Y-Direction - pounds
FMAX3	Maximum Shear Force in Beam Element Z-Direction - Pounds
FMAX4	Maximum Torque About Beam Element X-Axis - Inch * Pounds
FMAX5	Maximum Bending Moment About Beam Element Y-Axis - Inch * Pounds
FMAX6	Maximum Bending Moment About Beam Element Z-Axis - Inch * Pounds

REMARKS:

(1) Optional data card(s).
(2) "NFBM" on card 0050 specifies the number of these cards for input.
(3) The standard of default values for maximum rupture forces and moments are 1.E10 pounds and inch-pounds, respectively.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Blank entries are read as zero.
(6) The beam element coordinate systems are shown in Figure 2-5.
(7) All values are input as positive numbers.
(8) The input values are compared to the time-varying beam loads at the j end of the beam to determine if beam rupture occurs.
(9) Format for this card is (2(I2, I3), 6E10.0).

CARDS 2600: NON-STANDARD MAXIMUM BEAM ELEMENT NEGATIVE LOADS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum forces and moments for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	FMAXN1	FMAXN2	FMAXN3	FMAXN4	FMAXN5	FMAXN6	X	
	3		7	10.0E10	1000.0	10.0E10	10.0E10	10.0E6	10.0E10		2600

FIELD	CONTENTS
M	Massless Node Point Number at End 'I' (Right Justified Integer)
I	Mass Point Number at End 'I' (Right Justified Integer)
N	Massless Node Point Number at End 'J' (Right Justified Integer)
J	Mass Point Number at End 'J' (Right Justified Integer)
FMAXN1	Maximum Axial Force In Beam Element X-Direction – Pounds
FMAXN2	Maximum Shear Force In Beam Element Y-Direction – Pounds
FMAXN3	Maximum Shear Force In Beam Element Z-Direction – Pounds
FMAXN4	Maximum Torque About Beam Element X-Axis – Inch * Pounds
FMAXN5	Maximum Bending Moment About Beam Element Y-Axis – Inch * Pounds
FMAXN6	Maximum Bending Moment About Beam Element Z-Axis – Inch * Pounds

REMARKS:

(1) Optional data card(s).
(2) 'NFBMN' on card 0050 specifies the number of these cards for input.
(3) The standard or default values for maximum rupture forces and moments are 1.E10 pounds and inch-pounds, respectively.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Blank entries are read as zero.
(6) The beam element coordinate systems are shown in Figure 2-5.
(7) All values are input as positive numbers.
(8) The input values are compared to the time-varying beam loads at the j end of the beam to determine if beam rupture occurs.
(9) Format for this card is (2(I2, I3), 6E10.0).

CARDS 2700: LOAD INTERACTION CURVE SIGN CONVENTION DATA

DESCRIPTION: Defines the sign conventions to be used for load-interaction data output.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8
ISCV1	ISCV2	ISCV3	ISCV4	ISCV5	ISCV6			
3	-2	5	6	-4	1			2700

FIELD: CONTENTS

ISCV1 - ISCV6: CALAC (Lockheed-California Co.) sign convention load number to be used for the corresponding user defined loads. The above example results in the following correspondence between the user-defined loads and the CALAC sign convention loads:

User Loads	1	2	3	4	5	6	are made up of
CALAC Loads	3	-2	5	6	-4	1	

REMARKS:

(1) Optional data card(s).
(2) NSCV on card 0060 defines the number of these cards for input.
(3) Any nonzero ISCN on the 2800-series cards requires a corresponding sign convention definition card in the 2700 series.
(4) Section 3.1 describes the load-interaction data and the significance of the user-defined sign conventions.
(5) The format for this card is 6I5

CARDS 2800: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the beams to be analyzed for load-interaction curves, the two interacting load directions, sign conventions to be applied, exact location along the beams and rupture ratio.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890											
IJ	K	L	NLIL	ISCN	NSMI	FSLIC	BLLIC	WLLIC	RUPRAT		
7	3	5	3	1	10	1160.			1.4		**2800**

FIELD	CONTENTS
IJ	Beam number, the internal loads from which are to be analyzed on load-interaction diagrams.
K,L	Load directions for the x and y axes of load-interaction curve. In the above example, 3,5 means use Fz and My, in the user-defined sign convention.
NLIL	Number of sloping load-interaction lines, the data for which is defined on the 3000-series cards. The maximum allowed per load-interaction diagram is 20, including those lines generated as mirror images.
ISCN	User-defined sign convention number to be applied to the beam internal loads before selecting the K,L loads for this load interaction diagram. If ISCN = 0, then the CALAC internal load sign convention, defined in Section 4.15 reference 1, is used.
NSMI	Number of masses involved if shear and moment summation of a particular station is required.
FSLIC, BLLIC, WLLIC	Defines the location on the airplane for this load-interaction curve. Input only one of these nonzero. For fore-aft beams, use FSLIC. For lateral beams use BLLIC. For vertical beams, use WLLIC. The location input must be physically within the end points of beam IJ. In the example shown, a load-interaction curve is defined for beam number 7, which is a fore-aft beam, at FS 1160.
RUPRAT	Beam IJ will rupture when the maximum load ratio for this interaction curve exceeds RUPRAT. If the input data on cards 2900 and 3000 define a strength envelope which at any point would cause complete failure of the structure represented by beam IJ, then RUPRAT = 1.0 would be appropriate. A very large value (RUPRAT = 1000) will guarantee that beam rupture is not triggered by the load-interaction curve calculations.

REMARKS:

(1) Optional data card. NLIC on card 0060 defines the number of these cards to be input.

(2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.

(3) Section 3.1 describes the load-interaction calculations and data.

(4) Format for this card is (6I5, 4E10.0).

CARDS 2900: LOAD INTERACTION CURVE DATA

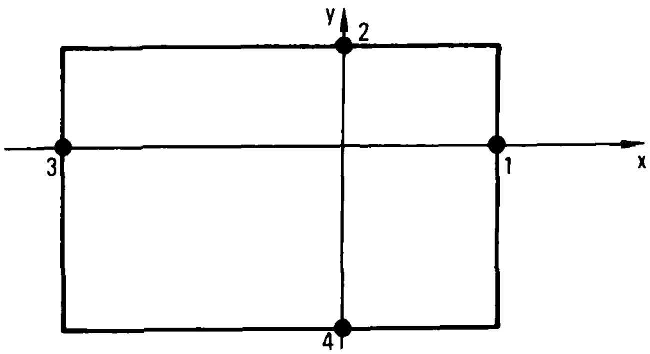
DESCRIPTION: Defines the maximum load levels along the positive and negative x and y load axes.

FORMAT AND EXAMPLE:

0 1 2 3	4	5	6	7		8
123456789012345678901234567890	1234567890	1234567890	1234567890	1234567890	123456	7890
	FMXLIC1	FMXLIC2	FMXLIC3	FMXLIC4		
	254000.	74.0E06	-254000.	-74.0E06		**2900**

FIELD	CONTENTS
FMXLIC1 FMXLIC2 FMXLIC3 FMXLIC4	Maximum load levels along the positive and negative x and y load axes. Sequence is as follows: 1 = + x axis 2 = + y 3 = - x 4 = - y

These lines form a rectangular load-interaction strength envelope that looks like:



REMARKS:

(1) Optional data card. NLIC on card 0060 defines the number of these cards to be input.

(2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.

(3) Section 3.1 describes the load-interaction calculations and data.

(4) Format for this card is (30X, 4E10.0).

(5) A zero or blank input for any of these 4 values will invoke a default value of 1.E20 pounds or inch-pounds.

(6) FMXLIC3 and FMXLIC4 are input as negative numbers.

CARDS 3000: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the intercepts for sloping load interaction lines and mirror image flags for generating these lines in other load quadrants.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	

MXY1	MXY2	FLIC1	FLIC2		
1	1	1500.	30.E06		3000

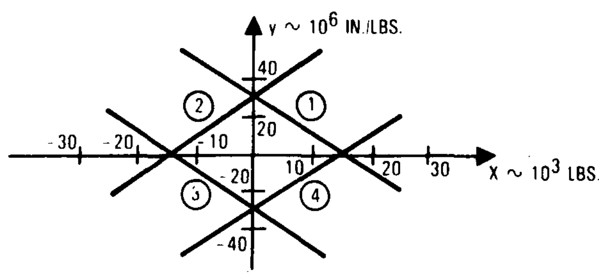
FIELD CONTENTS

MXY1
MXY2
Mirror image flags defining additional load-interaction lines that are generated internally in KRASH, based on the line defined by FLIC1 and FLIC2. The following combinations are possible:

MXY1	MXY2	RESULT	Total No. of L.I. Lines
0	0	No mirror images generated	1
0	1	Mirror about y axis only	2
1	0	Mirror about x axis only	2
1	1	Mirror about x and y axes	4

FLIC1
FLIC2
Intercept of sloping load-interaction line with x (FLIC1) and y (FLIC2) axes. These two numbers define a single load interaction line, while MXY1 and MXY2 can be used to generate additional lines which are symmetrical about the x, y or both axes.

REMARKS:
(1) Optional data. NLIC on Card 2800 defines the number of these cards to be input
(2) For ecah load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.
(3) Section 3.1 describes the load-interaction calculations and data.
(4) Format for this card is (2I5, 2E10.0)..
(5) For each load-interaction curve, a maximum of 20 load-interaction lines are allowed. The limit of 20 includes any lines generated by KRASH through nonzero inputs of MXY1 and MXY2.
(6) The example data will generate the following load-interaction strength envelope:



Load-interaction line 1 is generated by the user-input FLIC1 and FLIC2. Lines 2-4 are generated by KRASH because MXY1 = MXY2 = 1.

CARDS 3010: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines water line at forward and aft ends of segment for which shear and moment loads are to be summed.

FORMAT AND EXAMPLE:

0 1	2	3 4 5 6 7 8
1234567890	1234567890	1234567890123456789012345678901234567890123456789012345678901234567890
WLSMF	WLSMA	
215.7	206.4	

FIELD	CONTENTS
WLSMF	Water line at beam forward end.
WLSMA	Water line at beam aft end.

REMARKS:
(1) Optional data card. Use only if WSMI on card 2800 is > 0.
(2) Beam number (IJ) is defined.
(3) Format for this card is (2E10.0).

CARDS 3020: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines masses located at station for which shear and moment loads are to be summed.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890		2 1234567890		3 1234567890		4 1234567890		5 1234567890		6 1234567890		7 1234567890		8
IJSM1	IJSM2	IJSM3	IJSM4	IJSM5	IJSM6	IJSM7	IJSM8	IJSM9	IJSM 10	IJSM 11	IJSM 12	IJSM 13	IJSM 14		
33	41	49	57	65	84	104	105	118	119						

FIELD	CONTENTS
IJSM1 thru IJSM14	Mass Point Number (Right Justified Integer)

REMARKS:

(1) Optional data card. Use only if NSMI on card 2800 is > 0.
(2) Masses designed. IJSM1 thru IJSM14 must all be at same FS or BL station.
(3) 14 masses per card. Use NSMI/14 cards.
(4) Format for this card is (14I5).

KRASH INPUT DATA

CARDS 3100: MISCELLANEOUS MASS POINT PARAMETERS

DESCRIPTION: Defines any nonzero aerodynamic lift forces, angular moments of rotating masses, and mass cross products of inertia for mass points in the KRASH model.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7		8
12	345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2	34567890
I	LC	HEX	HEY	HEZ	XYI	YZI	XZI	NHSY	
7	0.0	100.0	0.0	0.0	1.3	−3.3	0.0	0	3100

FIELD CONTENTS

FIELD	CONTENTS
I	Mass Point Number (Right Justified Integer)
LC	Lift Coefficient For Aerodynamic Force, Positive Up
HEX	Angular Momentum of Rotating Masses About Mass Point X-Axis – Inch * Pound * Second
HEY	Angular Momentum of Rotating Masses About Mass Point Y-Axis – Inch * Pound * Second
HEZ	Angular Momentum of Rotating Masses About Mass Point Z-Axis – Inch * Pound * Second
XYI	Mass Cross Product of Inertia in Mass Point X-Y Plane – Inch * Pound * Second **2
YZI	Mass Cross Product of Inertia in Mass Point Y-Z Plane – Inch * Pound * Second **2
XZI	Mass Cross Product of Inertia in Mass Point X-Y Plane – Inch * Pound * Second **2
NHSY	Symmetry flag which defines the signs for HEX, HEY, HEZ for masses on the right side of the airplane, generated by subroutine GENMOD, if RUNMOD on card 110 is 2.

REMARKS:

(1) Optional data card(s).
(2) 'NHI' on card 0050 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) The airplane weight is multiplied by the lift coefficient to generate an aerodynamic lift force on the mass point. This lift acts upward in ground axes.
(5) Format for this card is (I2, E8.0, 6E10.0, I2)
(6) NHSY = 0 corresponds to a symmetrical model (counter-rotating engines), so that

HEX-RIGHT = -HEX LEFT
HEY-RIGHT = +HEY LEFT
HEZ-RIGHT = -HEZ LEFT

NHSY = 1 corresponds to an anti-symmetrical model (engines rotate in same direction), so that

HEX-RIGHT = +HEX LEFT
HEY-RIGHT = -HEY LEFT
HEZ-RIGHT = +HEZ LEFT

CARD 3200: MASS POINT EULER ANGLES

DESCRIPTION: Defines for any mass point in the KRASH model three Euler angles to arbitrarily rotate the mass point or body coordinate system relative to the airplane coordinate system.

FORMAT AND EXAMPLE:

0 1234567890		2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890		8
I	X	PHIDP	THEDP	PSIDP	X	X	X	X	
3		0.157	0.0	0.0					3200

FIELD	CONTENTS
I	Mass Point Number (Right Justified Integer)
PHIDP	Roll Euler Angle about Airplane X-Axis - Radians
THEDP	Pitch Euler Angle about Airplane Y-Axis - Radians
PSIDP	Yaw Euler Angle about Airplane Z-Axis - Radians

REMARKS:

(1) Optional data card(s).
(2) "NPH" on card 0050 specifies the number of these cards for input.
(3) Euler angles are order-dependent rotations. The order is PSIDP, THEDP, PHIDP.
(4) Blank entries are read as zero.
(5) These angles relate the mass-fixed axes to the airplane axes. Normally these axes coincide and therefore the angles are zero. If mass inertia were available in an inclined axis system the user might want to utilize this option. Another reason for inclining mass axes away from the airplane axes is to enable the user to orient an external spring in a direction that doesn't coincide with any of the airplane axes (external springs must point along one of the mass fixed axes).
(6) Roll angle positive when mass axes are "right-wing-down" relative to cg axes. Pitch angle positive when mass axes are "nose-up" relative to cg axes. Yaw angle positive when mass axes are "nose-right" relative to cg axes.
(7) Format for this card (I5, 5X, 3E10,0).

CARDS 3300: MASS POINT AERODYNAMIC COEFFICIENTS

DESCRIPTION: Defines for any mass point 6 aerodynamic load coefficients to be used to calculate aerodynamic loads.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
I	╳	CXAIR	CYAIR	CZAIR	CLAIR	CMAIR	CNAIR	
13		-137.	0.	-1500.	3500.	5200.	7100.	3300

FIELD	CONTENTS
I	Mass point number
CXAIR	Aerodynamic drag coefficient, in^2
CYAIR	Aerodynamic side force coefficient, in^2
CZAIR	Aerodynamic lift coefficient, in^2
CLAIR	Aerodynamic rolling moment coefficient, in^3
CMAIR	Aerodynamic pitching moment coefficient, in^3
CNAIR	Aerodynamic yawing moment coefficient, in^3

REMARKS:
(1) Optional data card(s).
(2) NAERO on card 0050 specifies the number of these cards for input.
(3) The input aerodynamic coefficients are defined as follows:

CXAIR = S * CX alpha
CYAIR = S * CY beta
CZAIR = S * CZ alpha
CLAIR = S * b * CL beta
CMAIR = S * $\bar{c}$ * CM alpha
CNAIR = S * b * CN beta

where

S	=	Reference area, in^2
b	=	Reference span, in
$\bar{c}$	=	Reference mean aerodynamic chord, in.
alpha	=	Angle of attack, rad. Positive when mass is nose up relative to its velocity vector.
beta	=	Sideslip angle, rad. Positive when mass is nose left relative to its velocity vector.
CXalpha	=	Slope of aerodynamic drag (positive forward)versus alpha, 1/rad
CYbeta	=	Slope of aerodynamic side force (positive right) versus beta, 1/rad
CZalpha	=	Slope of aerodynamic vertical force (positive down) versus alpha, 1/rad

<u>REMARKS:</u>
(Continued)

CLbeta = Slope of aerodynamic roll moment (positive right wing down) versus beta, 1/rad
CMalpha = Slope of aerodynamic pitch moment (positive nose up) versus alpha, 1/rad
CNbeta = Slope of aerodynamic yaw moment (positive nose right) versus beta, 1/rad

(4) All data refer to the local mass defined by I, not to the entire airplane.
(5) Aerodynamic loads at zero ALPHA are not included in the calculations. If necessary, these can be included as external forces/moments in the 3300 series cards.
(6) Aerodynamic loads using these coefficients are not included in the balanced initial conditions coding.
(7) The format for this card is (I5,5X,6E10.0).

KRASH INPUT DATA

CARDS 3400: MASS POINT TIME HISTORY ACCELERATION PARAMETERS

DESCRIPTION: Defines the mass point number, degree-of-freedom, and number of data points to specify an acceleration or load time history for any mass point in the KRASH model.

FORMAT AND EXAMPLE:

0 12345	1 67890	 12345	2 67890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1	 234567890
I	L	NP	NCODE							
3	2	10	1							3400

FIELD	CONTENTS
I	Mass Point Number.
L	Degree-of-Freedom where L = 1, 2, 3, 4, 5, 6 corresponds to X, Y, Z, θX, θY, θZ in the Mass Point Coordinate System
NP	Number of Data Points in the Table that specifies the Acceleration or Load Time History
NCODE	Flag defining whether the input table is of mass point acceleration or applied load.

REMARKS:

(1) Optional data card(s).
(2) "NACC" on card 0040 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) Each use of this card requires that "NP" number of the 3500-series cards be used.
(5) The masses must be input in sequence starting with the lower numbered masses.
(6) Format for this card is 4I5.
(7) NCODE = 0 for acceleration input table
NCODE = 1 for force/moment input table
(8) It is permissible to input forces for some masses and accelerations for other masses. If both types are input for the same mass, the accelerations will predominate.

CARDS 3500: MASS POINT ACCELERATION OR LOAD TIME HISTORY DATA TABLE

DESCRIPTION: Defines a table of time and acceleration or load data points for each mass point specified on the 3400-series cards.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8
T	ACCEL							
0.01	-0.6							3500

FIELD CONTENTS

T Time - Seconds

Accel Acceleration G's or Radians per Second **2 or Loads Pounds or Inch-Pounds

REMARKS:

(1) Optional data cards.
(2) For each of the "NACC" number of 3400-series cards, "NP" number of these cards are required.
(3) Within each set of data, the "NP" cards must be arranged in ascending order of time.
(4) Each set of data must be ordered to correspond with the 3400 series cards.
(5) Blank entries are read as zero.
(6) A maximum of 5000 acceleration times are allowed. For example, if accelerations are applied to 50 masses, the time history of each location can not exceed a curve consisting of 100 points.
(7) The values of acceleration or load are in mass axes, with translational accelerations in g's and rotational accelerations in rad/sec^2. Loads are in pounds or inch-pounds. (See Equation 1-117 Volume I).
(8) Format for this card is 2E10.0.

KRASH INPUT DATA

CARDS 3600: DIRECT INPUT OF BEAM ELEMENT 6X6 STIFFNESS MATRIX

DESCRIPTION: Defines the end points and 6x6 stiffness matrix terms for any beam element in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J								
	2	1	7								2400

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K11	K12	K13	K14	K15	K16			
3500.0	0.0	0.0	0.0	0.0	0.0			2401

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K21	K22	K23	K24	K25	K26			
0.0	1.7E07	0.0	0.0	0.0	−2.2E05			2402

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K31	K32	K33	K34	K35	K36			
0.0	0.0	1.7E07	0.0	0.3E05	0.0			2403

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K41	K42	K43	K44	K45	K46			
0.0	0.0	0.0	15200.0	0.0	0.0			2404

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K51	K52	K53	K54	K55	K56			
0.0	0.0	0.3E06	0.0	3.5E09	0.0			2405

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K61	K62	K63	K64	K65	K66			
0.0	−2.2E05	0.0	0.0	0.0	3.5E09			2406

CARDS 3600: **DIRECT INPUT OF BEAM ELEMENT 6X6 STIFFNESS MATRIX** (Continued)

FIELD	CONTENTS
M	Massless Node Point Number at end "I" (Right Justified Integer)
I	Mass Point Number at end "I" (Right Justified Integer)
N	Massless Node Point Number at end "J" (Right Justified Integer)
J	Mass Point Number at end "J" (Right Justified Integer)
KIJ	Stiffness Matrix Terms - Pounds per Inch or Inch * Pounds per Radian

REMARKS:

(1) Optional data cards.
(2) "NKM" on card 0050 specifies the number of these card sets for input.
(3) Blank entries are read as zero.
(4) The beam element must be included on the 0900-series cards.
(5) The stiffness data on these cards will override any values calculated with the beam element section properties on the 0900-series cards.
(6) The input 6x6 stiffness matrix corresponds to the lower right-hand quadrant of a full 12x12 beam element stiffness matrix, shown as Equation (1-23) in Volume I.
(7) Entries requiring scientific notation (X.XEXX) should be right justified.
(8) Format for the beam identification card is 2(I2, I3).
(9) Format for the stiffness matrix data cards is 6E10.0.

CARDS 3700-3800: MASS POINT POSITION (STRUCTURE DEFORMATION) PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the planar view, scale factors, and mass point numbers for each mass point position (structure deformation) printer plot.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7	8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890

NTPL	NMPTS	ISCALE	X	XSCALE	YSCALE	X	X	X	X	
1	10	3		10.0	10.0					3700

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	X	
1	2	5	6	7	11	13	14	21	27						3800

FIELD CONTENTS

NTPL Flag to select Planar View where NTPL = 1, 2, 3 corresponds to top, side, and frontal views, respectively (Right Justified Integer)

NMPTS Number of Mass Points (Right Justified Integer - Maximum allowed is 50)

ISCALE Flag to Select Scaling Option as follows (Right Justified Integer):

ISCALE	TYPE OF SCALING
0	Automatic scaling where horizontal and vertical plot axes scales are selected independently based on the corresponding largest mass point displacement components.
1	Automatic scaling where horizontal and vertical plot axes scales are set equal based on largest mass point displacement component.
3	User defined scaling

XSCALE Horizontal Scale Factor required if "ISCALE" = 3

YSCALE Vertical Scale Factor required if "ISCALE" = 3

MI Mass Point Number (Right Justified Integer)

REMARKS:
(1) Optional data cards.
(2) "NPLT" on card 0140 specifies the number of these card sets for input.
(3) "NTPL," "NMPTS," and "MI" must be nonzero.
(4) Blank entries are read as zero.
(5) Scale factor units are inches of mass point displacement per inch of paper.
(6) Entries requiring scientific notation (X.XEXX) should be right justified.
(7) Recommend ISCALE = 3 if user plans to compare or overlay plots at different time periods.
(8) Format for card 3700 type is (3I5,5X,2E10.0).
(9) Format for card 3800 type is 14I5.

CARDS 3900: MASS POINT PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the mass point number and flags to specify which mass point output quantity time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 12345	1 67890	12345	2 67890	12345	3 67890	12345	4 67890	12345	5 67890	12345678901234567890	6 7 12345678901234567890		8 1234567890
I	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9				
3	0	1	0	1	0	0	1	0	1				3900

FIELD CONTENTS

- I — Mass Point Number
- MP1 — Flag for Linear Displacements (X, Y, Z - Inches) in the Ground Coordinate System
- MP2 — Flag for Euler Angles (PHI, THETA, PSI - Radians) in the Airplane Coordinate System
- MP3 — Flag for Linear Velocities (X, Y, Z - Inches per Second) in the Ground Coordinate System
- MP4 — Flag for Linear Velocities (U, V, W - Inches per Second) in the Mass Point or Body Coordinate System
- MP5 — Flag for Angular Velocities (P, Q, R - Radians per Second) in the Mass Point or Body Coordinate System
- MP6 — Flag for Unfiltered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
- MP7 — Flag for Filtered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
- MP8 — Flag for Angular Accelerations (P, Q, R - Radians per Second**2) in the Mass Point or Body Coordinate System
- MP9 — Flag for Impulse (X, Y, Z in G-sec., P, Q, R in (RAD Per Sec) in Mass Point or Body Coordinate Axes for Filtered Data

REMARKS:
(1) Optional data card(s).
(2) "NMEP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "I" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Format for this card is 10I5.

CARDS 4000: MASSLESS NODE POINT PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the massless node point number, mass point number, and flags to specify which massless node point output quantity time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 12345	1 67890	 12345	2 67890	 12345	3 67890	 12345	4 67890	 1234567890	5 1234567890	6 1234567890	7 1234567	8 890
M	I	NP1	NP2	NP3	NP4	NP5	NP6					
1	7	0	1	0	1	0	0					4000

FIELD CONTENTS

FIELD	CONTENTS
M	Massless Node Point Number
I	Mass Point Number
NP1	Flag for Linear Displacements (X, Y, Z - Inches) in the Ground Coordinate System
NP2	Flag for Linear Velocities (X, Y, Z - Inches per Second) in the Ground Coordinate System
NP3	Flag for Linear Velocities (U, V, W - Inches per Second) in the Mass Point or Body Coordinate System
NP4	Flag for Unfiltered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
NP5	Flag for Filtered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
NP6	Flag for Impulse (X, Y, Z in G-sec. P, Q, R in RAD/Sec) in Mass Point or Body Coordinate System

REMARKS:

(1) Optional data card(s).
(2) "NNEP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "M" and "I" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Format for this card is 8I5.

CARDS 4100: BEAM ELEMENT LOADS PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam element internal load time histories will be printer plotted.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I0	BFP1	BFP2	BFP3	BFP4							
27	0	1	0	1							4100

FIELD	CONTENTS
IJ	Beam Element Number
BFP1	Flag for Axial and Shear Forces (FX, FY, FZ - Pounds)
BFP2	Flag for Torque and Bending Moments at End "I" (MX, MY, MZ - Inch * Pounds)
BFP3	Flag for Torque and Bending Moments at End "J" (MX, MY, MZ - Inch * Pounds)
BFP4	Flag for choosing between beam axis loads or loads in mass axes.

REMARKS:

(1) Optional data card(s).
(2) "NBFP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) *"IJ" must be nonzero.*
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) If BFP4 = 0, then all load data are in the beam element coordinate system shown in Figure 2-5.
If BFP4 = 1, then all load data are in the mass point coordinate system at mass i or j, as appropriate.
(8) If BFP4 = 1, then BFP1 through BFP3 control plotting of the following:
BFP1: FX,FY,FZ at mass I, in mass point coordinate system
BFP2: FX,FY,FZ at mass J, in mass point coordinate system
BFP3: MYI and MYJ, moments about y axis in each mass point coordinate system.
(9) Format for this card is 5I5.

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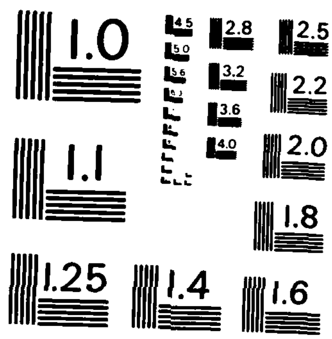
LR-30777 DOT/FAA/CT-85-10 DTFA03-83-C-00004

UNCLASSIFIED   F/G 1/3   NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CARDS 4200: BEAM ELEMENT DEFLECTION-ROTATION PRINTER PLOT PARAMETERS

DESCRIPTION Defines the beam element number and flags to specify which beam element deflection and rotation time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
IJ	BDP1	BDP2	BDP3					
3	0	0	1					4200

FIELD CONTENTS

IJ Beam Element Number
BDP1 Flag for Deflection Differences of End "J" and End "I" (X, Y, Z - Inches)
BDP2 Flag for Rotation Differences of End "J" and End "I" (Phi, Theta, Psi - Radians)
BDP3 Flag for Rotation Sums of End "J" and End "I" (Phi, Theta, Psi - Radians)

REMARKS

(1) Optional data card(s).
(2) "NBDP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "IJ" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) All deflection-rotation data is output in the beam element coordinate systems shown in Figure 2-3.
(8) Format for this card is 4I5.

CARDS 4300: BEAM ELEMENT STRESS RATIO PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam element stress ratio time histories will be printer plotted.

FORMAT AND EXAMPLE:

0	1	2	3		4	5	6	7			8
1234567	89012345	67890123	45678901	2345	678901234567890123456789012345678901234567						890
IJ	STP1	STP2	STP3	STP4	STP5	X	X	X	X	X	
7	0	1	1	0	0						4300

FIELD	CONTENTS
IJ	Beam Element Number
STP1	Flag for Stress Ratio for Top and Bottom Fibers Using Maximum Shear Stress Theory
STP2	Flag for Stress Ratio of Left and Right Fibers Using Maximum Shear Stress Theory
STP3	Flag for Stress Ratio of Top and Bottom Fibers using Constant Energy of Distortion Theory
STP4	Flag for Stress Ratio of Left and Right Fibers Using Constant Energy of Distortion Theory
STP5	Flag for Stress Ratio of Tension-Only, Compression-Only, and Axial Buckling Loads

REMARKS:

(1) Optional data card(s).
(2) "NSTP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "IJ" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Stress parameters must be provided for the beam elements on the 0900-series cards.
(8) "NSC" on card 0050 must be flagged "yes."
(9) Format for this card is 6I5.

CARDS 4400: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the end point and flags to specify which external crushing spring load and deflection time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 12345	1 67890	 12345	2 67890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	 1	8 234567890
I	M	SEP1	SEP2							
3	1	1	0							**4400**

FIELD	CONTENTS
I	Mass Point Number
M	Massless Node Point Number
SEP1	Flag for Axial Deflection (Inches)
SEP2	Flag for Axial Loads (Pounds)

REMARKS:
(1) Optional data card(s).
(2) "NSEP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "I" *must be nonzero.*
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) All external crushing springs attached to the same mass point/massless node point will be printer plotted if that end point is specified.
(8) Format for this card is 4I5.

CARDS 4500: BEAM ELEMENT STRAIN AND DAMPING ENERGY PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam internal element strain and damping energy time history will be printer plotted

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

IJ	ENG1	ENG2								
2	1	1								4500

FIELD CONTENTS

IJ Beam Element Number
ENG1 Flag for Strain Energy (in.-lb.)
ENG2 Flag for Damping Energy (in.-lb.)

REMARKS:
(1) Optional data cards.
(2) "NENP" on card 0140 specifies the number of these cards for input.
(3) All entries must be right justified.
(4) "IJ" must be nonzero.
(5) *Blank entries are read as zero.*
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Format for this card is 3I5.

CARDS 4600: DYNAMIC RESPONSE INDEX (DRI) PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the mass point number of a DRI beam element for dynamic response index (DRI) time history printer plots.

FORMAT AND EXAMPLE:

0 12345	1 67890	2 1234567890	3 1234567890	4 1234567890	5 1234567890	6 1234567890	7 1234567890	8 1234567890
J	X	X	X	X	X	X	X	
27								4600

FIELD CONTENTS

J Mass Point Number

REMARKS:
(1) Optional data card(s).
(2) "NDRP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "J" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) The mass point number must be end "J" of a DRI beam element.
(8) Format for this card is I5.

CARD 4700: END OF DATA

DESCRIPTION: Defines the final card of the input data.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 1234567890123456789012345678901234567890123456789012345678901234567890	8 1234567890
END	
END	4700

FIELD CONTENTS

End The Mnemonic "End" (Left Justified)

REMARKS: (1) Required data card.

2.3 OUTPUT AND SAMPLE CASE

As explained in Section 2.1, the most general case of a KRASH85 analysis involves the use of three separate programs: KRASHIC, MSCTRAN, and KRASH85. Table 2-6 shows a summary of the output from each program. A sample case which models one-half of a transport airplane with 21 masses and 28 internal beams will be used to illustrate the output for each program. This model is illustrated in figure 2-7. This is a test case with special elements for checkout purposes; it does not represent a realistic airplane model.

TABLE 2-6. SUMMARY OF KRASH85 OUTPUT

KRASHIC	KRASH85

• Echo of input data (2 times)
• Formatted printout of input data
• Miscellaneous calculated data
 	
MSCTRAN
 	
• Executive control deck echo
• Case control deck echo
• Input bulk data deck echo
• Sorted bulk data deck echo
• Displacement vector
• Load vector
• Forces of single-point constraint
• Forces in bar elements
• Element strain energies
• Grid point force balance
	• Echo of input data (2 times)
	• Formatted printout of input data
	• Miscellaneous calculated data
	• Time histories of model responses
	    • Mass data
	    • Internal beam data
	    • External spring data
	    • Energy data
	• Summaries at end of run
	    • External spring loading/unloading
	    • Summary of plastic hinge formations
	    • Summary of internal beam yielding and rupture
	    • Summary of energy distribution
	    • Interaction load time-histories
	    • Vehicle c.g. motion time-histories
	    • Time history plots of selected response quantities

2.3.1 KRASHIC Output

2.3.1.1 Echo of Input Data

This is a direct listing of the input data cards for the case being analyzed. Figure 2-8 illustrates this print for the sample case. Each

page of the listing is preceded by a heading which identifies the column number. The sequence numbers are in columns 77 - 80. The first card, with a 1 in column 10, is generated by the Job Control Language (JCL), and is not part of the data set (LT.SAMPLE.DATA in this case) in the user's library. This first card tells the program whether or not to read an additional data set of static deflections. A value of 1 means read the additional data set, 0 means don't read it. The JCL is set up to supply a zero for this card for the first iteration, when no static deflection information is available, and a 1 for all subsequent iterations, when the data are available, as generated by NASTRAN. The listing in figure 2-8 is from the last iteration, and therefore the first card has a 1 in column 10. To reiterate, this card is automatically generated by the JCL; the user does not supply this card.

Cards 10 through 3480 are supplied by the user and represent the basic KRASH85 data set described in Section 2.2. This is the data set referred to as XYZ.DATA in Section 2.1. Note how the dummy title cards serve to segment the date and facilitate reviewing and editing the data set.

Following card 3480 is a set of cards numbered 1 through 76. This is the static deflection data set referred to as XYZ.NASOUT.DATA in Section 2.1. The first six cards of this data set are title cards, the remaining cards are the three deflections and three rotations of each grid point in the NASTRAN model used to solve the static loads problem. Cards 1 through 76 are all generated automatically; the user does not have to develop this data set. The data set will reside in the user's library under the name XYZ.NASOUT.DATA.

The complete echo shown in figure 2-8 is provided twice. One copy can be used to mark up for forming a new data set, while the other copy remains as a clean record of the input for the current case.

2.3.1.2 Formatted Print-Out of Input Data

This section of the print output organizes all the input data into logical groups and prints out the data with self-explanatory identification headings. This output is illustrated in figure 2-9 for the sample case. The data are organized into the following major groups:

- Case title cards
- Program size data
- Acceleration data transfer control parameters
- Program data management control data (restart option)
- Program control data
- Vehicle initial conditions
- Initial mass/node point deflections (read from XYZ.NASOUT.DATA)
- Generalized surface data
- Corresponding mass and beam numbering (RUNMOD = 2 only)
- Mass data
- Node point data (optional)
- External spring data (optional)
- Material properties
- Internal beam data
- Unsymmetrical beam data (optional)
- Plastic hinge and end-fixity data (optional)
- Oleo strut beam data (optional)
- Nonlinear beam data (optional)
- Volume penetration data (optional)
- DRI elements (optional)
- Volume change data (optional)
- Nonstandard maximum deflections (optional)
- Nonstandard maximum forces (optional)
- Load interaction curve sign conventions and curve data (optional)
- Nonzero angular momenta, cross-products of inertia, lift constants (optional)

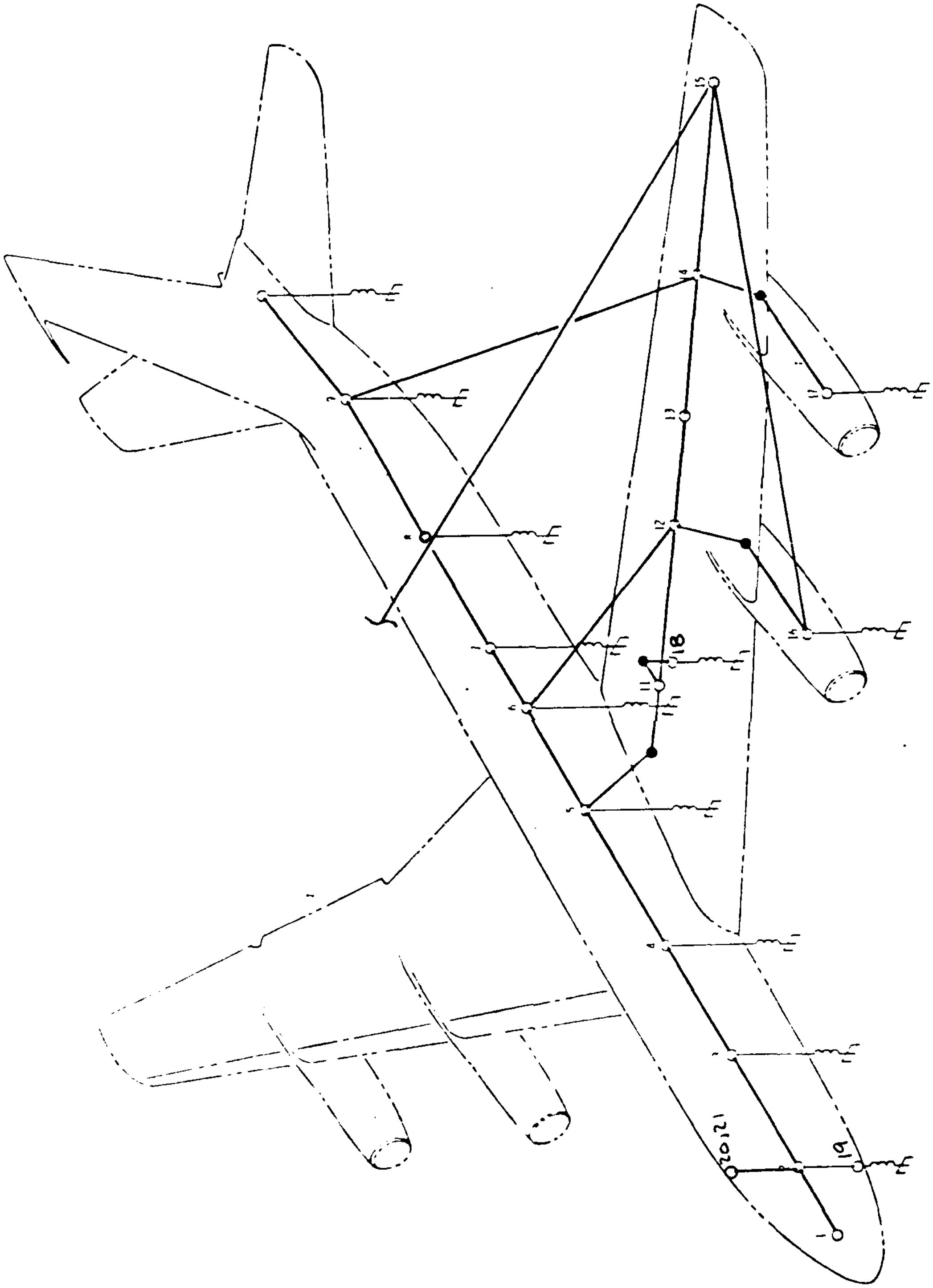


FIGURE 2-7. LARGE TRANSPORT AIRPLANE MODEL - SAMPLE CASE

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    1          1
    2    LT.SAMPLE.DATA                                                                00000010
    3    21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL                       00000020
    4    1234567890123456789012345678901234567890123456789012345678901234567890120000003 0
    5       NM  NSP   NB  NLB  NNP NPIN  NUB NDRINOLEO NACC  MVP NVCH NMTL   ND 00000040
    6       21   19   28    1   12   10    4    1    2   19    0    0    0    0 00000050
    7     NVBM NFBMNVBMNNFBMN  NKM  NHI  NPH TOL1 TOL2 TOL3  NSC  NICNAERONBOMB 00000060
    8        0    2    0    2    0    2    2 1000 1000 1000    1    1    0    1 00000070
    9     NSCV NLICNWRGR NBAL  ICDICITR                                         00000080
   10        1   15    0    5    1    1                                         00000090
   11    GRAPHICS                                                               00000100
   12                                                                           00000110
   13                                                                       200 00000120
   14    ONE RESTART AND ONE SAVE CARD FOLLOWS                                  00000130
   15                                                                           00000140
   16                                                                           00000150
   17         IPRINT  DELTAT   TMAX      PLOWT      FCUT       RUNMOD          00000160
   18            200  .000050  0.1       0.000      50.         1.             00000170
   19    BLANK CARD FOLLOWS                                                     00000180
   20                                                                           00000190
   21      NSF  NTF  NDE NSPD  NED   NS  NRP NIMP  NBC : PRINT DATA             00000200
   22        1    1    1    1    1    0    1    0    1                         00000210
   23     NMEP NNEP NBFP NBDP NSTP NSEP NENP NDRP NPLTNPFCT : PLOT DATA         00000220
   24        0    0    6    0    0    0    0    0    0    0                    00000230
   25    INITIAL CONDITION DATA : 3 CARDS                                       00000240
   26      3140.00    000.00    300.00                                          00000250
   27       000.00    0.1       000.00                                          00000260
   28       000.00    .01745    000.00    000.00    000.00     0.001.1463E-07   00000270
   29    MASS DATA : NM CARDS                                                   00000280
   30       1585.0     199.0       0.0    220.0.11514E+05.4     E+05.15   E+05 100000290
   31       9064.5     300.0       0.0    218.7.89080E+05.3     E+06.99   E+05 200000300
   32      15318.1     460.0       0.0    208.7.16278E+06.96935E+05.10309E+06 300000310
   33      13096.0     620.0       0.0    206.0.19627E+06.66715E+05.79389E+05 400000320
   34      21752.6     820.0       0.0    200.2.49106E+06.12567E+06.14651E+06 500000330
   35       7901.5     960.0       0.0    212.4.81383E+05.12    E+06.2    E+06 600000340
   36       9190.7    1040.0       0.0    207.9.87536E+05.14    E+06.2    E+06 700000350
   37       9938.4    1200.0       0.0    225.1.88098E+05.18    E+06.3    E+06 800000360
   38       5702.0    1359.9       0.0    260.0.96249E+05.41788E+05.26039E+05 900000370
   39       6175.2    1570.0       0.0    302.3.21530E+06.10798E+06.15863E+06 1000000380
   40       9670.6     801.3     118.3    188.3.15213E+05.13858E+06.36    E+06 1100000390
   41      10065.6     852.3     271.8    203.1.19510E+05.12263E+06.3     E+06 1200000400
   42       5286.5     943.5     430.7    219.9.72715E+04.52619E+05.11    E+06 1300000410
   43       3759.0    1045.8     583.5    243.5.44083E+04.25823E+05.60    E+05 1400000420
   44       1542.3    1112.6     740.6    255.1.16708E+04.90137E+04.18    E+05 1500000430
   45       5400.0     719.0     321.6    165.8 3651.56   25746.    29374.6   1600000440
   46       5151.0     902.8     551.6    188.1 3712.     24588.2   28178.    1700000450
   47       1922.0     887.0     131.6     90.7 371.     1600.      2000.     1800000460
   48        238.0     279.0       0.0     85.0 24.       300.       500.     1900000470
   49       1000.      300.0       0.0    238.7  1000.     1000.     1000.    2000000480
   50       1000.      300.0       0.0    238.7  1000.     1000.     1000.    2100000490
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 1 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                   1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

     51  NODE POINT DATA : NNP CARDS                                                 00000500
     52      1    5     775.1      48.0     181.0                                    00000510
     53      1   11     773.9     118.3     186.3                                    00000520
     54      2   11     887.0     131.6     179.7                                    00000530
     55      3   11     887.0     131.6     179.7                                    00000540
     56      1   12     811.8     321.6     199.6                                    00000550
     57      1   14     994.5     551.6     220.5                                    00000560
     58      1   15    1148.0     740.6     261.3                                    00000570
     59      2   15    1112.6     740.6     255.1                                    00000580
     60      1   16     735.7     321.6     199.6                                    00000590
     61      2   16     719.0     321.6     165.8                                    00000600
     62      1   17     918.4     551.6     220.5                                    00000610
     63      1    2     279.0       0.0     147.5                                    00000620
     64  EXTERNAL SPRING DATA : 2 X NSP CARDS                                        00000630
     65      1    3       70.      0.35  175000.                                     00000640
     66      2    3      82.7      0.35  300000.0                                    00000650
     67      3    3      72.7      0.35  100000.0                                    00000660
     68      4    3      70.0      0.35  300000.0                                    00000670
     69      5    3      64.2      0.35  300000.0                                    00000680
     70      6    3      76.4      0.35  300000.0                                    00000690
     71      7    3      69.9      0.35  100000.0                                    00000700
     72      8    3      69.1      0.35  100000.0                                    00000710
     73      9    3      64.0      0.35  300000.0                                    00000720
     74     10    3      82.0      0.35  300000.0                                    00000730
     75     11    3       28.      0.35  100000.                                     00000740
     76     12    3       14.      0.35  100000.                                     00000750
     77     13    3       11.      0.35  100000.                                     00000760
     78     14    3        7.      0.35  100000.                                     00000770
     79     15    3         3.     0.35  100000.                                     00000780
     80     16    3      29.8      0.35  272000.                                     00000790
     81     17    3       28.      0.35  272000.                                     00000800
     82     18    3     19.65      0.30  100000.                                     00000810
     83     19    3     16.45      0.30  100000.                                     00000820
     84    1.3    1.5       1.6       10.       70000.     7000.     0.            00000830
     85    1.3    1.5       1.6       10.      140000.    14000.     0.00          00000840
     86    1.0    6.0       10.       21.      115000.    90000.     0.00          00000850
     87    1.0    1.1       2.0       3.0      340000.   200000.     0.00          00000860
     88    1.0    1.1       2.0       3.0      340000.   200000.     0.00          00000870
     89    1.0    1.1       2.0       3.0      340000.   200000.     0.00          00000880
     90    1.     6.        10.       21.       60000.    48000.     0.00          00000890
     91    1.     6.        10.       21.       68000.    48000.     0.00          00000900
     92    1.     1.1       2.0       3.       300000.    30000.     0.00          00000910
     93    1.     1.1       2.0       3.       300000.    30000.     0.00          00000920
     94    1.     1.5       2.        7.       330000.   330000.                   00000930
     95    1.     1.5       2.        7.       330000.   330000.     0.00          00000940
     96    1.     1.5       2.        7.       330000.   330000.                   00000950
     97    1.     1.5       2.        7.       330000.   330000.                   00000960
     98    1.     1.5       2.        7.       330000.   330000.     0.00          00000970
     99    1.     8.        9.        16.       10000.    30000.                   00000980
    100    1.     8.        9.        16.       10000.    30000.                   00000990
    101    2.     2.001     8.05      8.051     62200.   294700.      .02          00001000
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 2 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                   1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

   102   2.        2.001     5.75      5.751      16150.    51500.     .02          00001010
   103   INTERNAL BEAM DATA : NB CARDS                                               00001020
   104       1    2     32.00       0.00  6.20E+04  3.70E+04       0.00 96.0 96.0 500001030
   105       2    3     36.00       0.00  7.70E+04  4.30E+04       0.00 99.0 99.0 500001040
   106       3    4     36.00       0.00  8.60E+04  4.30E+04       0.00 56.0 56.0 500001050
   107       4    5     59.00       0.00 13.60E+04  4.65E+04       0.00 56.0 56.0 500001060
   108       5    6     59.00       0.00 11.60E+04  4.65E+04       0.00 66.0 66.0 500001070
   109       6    7     57.00       0.00 13.60E+04  5.70E+04       0.00 88.0 88.0 500001080
   110       7    8     48.00       0.00 11.40E+04  6.20E+04       0.00 91.0 91.0 500001090
   111       8    9     37.00       0.00  5.60E+04  3.35E+04       0.00 51.0 51.0 500001100
   112       9   10     25.00       0.00  9.00E+04  9.50E+03       0.00 50.0 50.0 500001110
   113       5 1 11     54.00 4.800E+04  1.59E+04  1.14E+05       0.00  1.0  1.0 500001120
   114   1 11    12     63.20 2.600E+04  1.14E+04  1.02E+05       0.00  1.0  1.0 500001130
   115      12   13     56.3  1.000E+04  4.70E+03  5.80E+04       0.00  1.0  1.0 500001140
   116      13   14     40.7  4.800E+03  2.00E+03  2.10E+04       0.00  1.0  1.0 500001150
   117      14 1 15     20.   2.700E+03  1.20E+03  8.00E+03       0.00  1.0  1.0 500001160
   118   1 12 1 16       8.0  2.208E+02  7.32E+02  1.00E+02       0.00  1.0  1.0 400001170
   119   1 14 1 17       8.0  2.208E+02  7.32E+02  1.00E+02       0.00  1.0  1.0 400001180
   120   2 11    18      0.01 150.0      239.E+00  239.E+00       0.00  1.0  1.0 100001190
   121   3 11    18    0.01   150.0      239.E+00  239.E+00       0.00  1.0  1.0 100001200
   122   1  2    19      0.01 5.         32.5E+00  32.5E+00       0.00  1.0  1.0 100001210
   123       6   12     40.7  4.800E+03  2.00E+03  2.10E+04       0.00  1.0  1.0 500001220
   124       9   14     40.7  4.800E+03  2.00E+03  2.10E+04       0.00  1.0  1.0 500001230
   125      12    0     40.7  4.800E+03  2.00E+03  2.10E+04       0.00  1.0  1.0 500001240
   126       2   20     10.     1.0       1.0       1.0           0.00  1.0  1.0 900001250
   127       2   21     10.     1.0       1.0       1.0           0.00  1.0  1.01000001260
   128      15   16     20.                                       0.00  1.0  1.0 500001270
   129   2 15 2 16      20.                                       0.00  1.0  1.0 500001280
   130      15    0     20.   2.700E+03  1.20E+03  8.00E+03       0.00  1.0  1.0 500001290
   131   2 15     0     20.   2.700E+03  1.20E+03  8.00E+03       0.00  1.0  1.0 500001300
   132   BEAM END FIXITY CARDS: NPIN CARDS                                            00001310
   133       1    2    0    0    1    1    0.         0.    0.0088     1.15          00001320
   134       2    3    0    0    1    1    0.         0.    1.25       1.25          00001330
   135       3    4    0    0    1    1    0.         0.    1.1        1.1           00001340
   136       4    5    0    0    1    1    0.         0.    1.15       1.15          00001350
   137       5    6    0    0    1    1    0.         0.    1.25       1.25          00001360
   138       6    7    0    0    1    1    0.         0.    1.25       1.25          00001370
   139       7    8    0    0    1    1    0.         0.    1.15       1.15          00001380
   140       8    9    0    0    1    1    0.         0.    1.0        1.0           00001390
   141       6   12    0    0    1    1    0.         0.    0.         0.            00001400
   142       9   14    0    1    0    1    0.         0.    0.         0.            00001410
   143   UNSYM BEAM DATA:  NUB CARDS                                                  00001420
   144      15   16    1         .08                                                  00001430
   145   2 15 2 16    -1         .08                                                  00001440
   146      15    0    1         .3                                                   00001450
   147   2 15     0   -1         .3                                                   00001460
   148   OLEO BEAM CARDS:                                                             00001470
   149            1.        1                                                         00001480
   150   2 11    18    20.982  10855.      739.     1.4       20.                     00001490
   151   1  2    19    16.965   3420.      289.     1.4       16.                     00001500
   152   2 11    18     4.0        0.      .1E06    .1E06    5000.             1      00001510
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 3 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                   1         2         3         4         5         6         7         8
CARD NO.  12345678901234567890123456789012345678901234567890123456789012345678901234567890

    153    1  2   19     3.4         0.        50.E03    50.E03    500.                 00001520
    154               45                                                                00001530
    155     -0.2        352.7                                                           00001540
    156     -0.0964     352.7                                                           00001550
    157     -0.0376      10.24                                                          00001560
    158      0.124       23.62                                                          00001570
    159      0.341       22.21                                                          00001580
    160      0.607       17.90                                                          00001590
    161      0.953        8.24                                                          00001600
    162      1.46         3.38                                                          00001610
    163      2.17         2.13                                                          00001620
    164      3.07         1.25                                                          00001630
    165      4.13         1.56                                                          00001640
    166      5.21         1.79                                                          00001650
    167      6.20         2.46                                                          00001660
    168      7.05         3.58                                                          00001670
    169      7.72         6.26                                                          00001680
    170      8.20        13.47                                                          00001690
    171      8.53        31.50                                                          00001700
    172      8.74        62.40                                                          00001710
    173      8.91        64.06                                                          00001720
    174      9.12        34.22                                                          00001730
    175      9.41        16.03                                                          00001740
    176      9.83         8.42                                                          00001750
    177     10.39         5.24                                                          00001760
    178     11.08         3.68                                                          00001770
    179     11.87         2.93                                                          00001780
    180     12.71         2.77                                                          00001790
    181     13.54         3.38                                                          00001800
    182     14.27         4.93                                                          00001810
    183     14.83         9.33                                                          00001820
    184     15.21        25.53                                                          00001830
    185     15.40       153.79                                                          00001840
    186     15.4518    1000.                                                            00001850
    187     15.4539    1000.                                                            00001860
    188     15.4581    1000.                                                            00001870
    189     15.494      403.85                                                          00001880
    190     15.61        67.70                                                          00001890
    191     15.84        22.15                                                          00001900
    192     16.18         9.93                                                          00001910
    193     16.65         5.31                                                          00001920
    194     17.21         3.02                                                          00001930
    195     17.82         2.07                                                          00001940
    196     18.39         0.92                                                          00001950
    197     18.82         0.                                                            00001960
    198     18.97        10.                                                            00001970
    199     22.          10.                                                            00001980
    200   DAMPC CARD                                                                    00001990
    201    .05                                                                          00002000
    202   NONLINEAR BEAM DATA: NLB + CARDS                                              00002010
    203    3 11   18     1     7   2.0                                                  00002020
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 4 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

   204   DRI CARD:                                                               00002030
   205       2   21                                                              00002040
   206   POS.FORCE CUTOFF:NFBM CARDS                                             00002050
   207    2 11    18    428000     1.E10    1.0E10     1.E10     1.E10     1.E10  00002060
   208    1  2    19    130000     1.E10     78000     1.E10     1.E10     1.E10  00002070
   209   NEG.FORCE CUTOFF:NFBMN CARDS                                            00002080
   210    2 11    18    428000     1.E10    1.0E10     1.E10     1.E10     1.E10  00002090
   211    1  2    19    130000     1.E10     78000     1.E10     1.E10     1.E10  00002100
   212   LOAD INTERACTION SIGN CONVENTIONS(NSCV CARDS):                          00002110
   213       1    2   -3    4    5    6                                          00002120
   214   LOAD INTERACTION DATA(NLIC+ CARDS):                                     00002130
   215       1    3    5    1    0       300.                           1000.    00002140
   216                                  166000.    20.8E+06 -166000.  -20.8E+06  00002150
   217       1    1 199000.   45.6 E+06                                          00002160
   218       2    3    5    1    0       300.                           1000.    00002170
   219                                  166000.    20.8E+06 -166000.  -20.8E+06  00002180
   220       1    1 199000.   45.6 E+06                                          00002190
   221       2    3    5    2    0       400.                           1000.    00002200
   222                                  210000.    23.8E+06 -210000.  -23.8E+06  00002210
   223       1    1 185000.   60.8 E+06                                          00002220
   224       1    1 674300.   25.4 E+06                                          00002230
   225       3    3    5    2    0       480.                           1000.    00002240
   226                                                                           00002250
   227       1    1 195000.  130.3 E+06                                          00002260
   228       1    1 545300.   28.9 E+06                                          00002270
   229       3    3    5    2    0       540.                           1000.    00002280
   230                                                                           00002290
   231       1    1 199000.  137.3 E+06                                          00002300
   232       1    11365380.   35.3 E+06                                          00002310
   233       3    3    5    2    0       620.                           1000.    00002320
   234                                  274000.    45.0E+06 -274000.  -45.0E+06  00002330
   235       1    1 286000.  185.6 E+06                                          00002340
   236       1    1 384400.   79.7 E+06                                          00002350
   237       4    3    5    2    0       620.                           1000.    00002360
   238                                  274000.    45.0E+06 -274000.  -45.0E+06  00002370
   239       1    1 286000.  185.6 E+06                                          00002380
   240       1    1 384400.   79.7 E+06                                          00002390
   241       5    3    5    2    1       960.                           1000.    00002400
   242                                  288000.             -288000.             00002410
   243       1    0-5.2317E06  71.5E+06                                          00002420
   244       1    1 474500.  152.8E+06                                           00002430
   245       6    3    5    2    1       960.                           1000.    00002440
   246                                  288000.             -288000.             00002450
   247       1    0-5.2317E06  71.5E+06                                          00002460
   248       1    1 474500.  152.8E+06                                           00002470
   249       6    3    5    2    1      1000.                           1000.    00002480
   250                                  254000.    74.0E+06 -254000.  -74.0E+06  00002490
   251       1    1 301000.  228.7E+06                                           00002500
   252       1    11.3581E 06  84.2E+06                                          00002510
   253       7    3    5    3    1      1080.                           1000.    00002520
   254                                                                           00002530
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 5 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    255      0    1 210000.  -555.88E06                                          00002540
    256      1    1 327700.   107.75E06                                          00002550
    257      1    1 1.5738E06  64.0 E06                                          00002560
    258      7    3    5    3    1      1160.                           1000.    00002570
    259                                                                          00002580
    260      0    1 239000.  -265.64E06                                          00002590
    261      1    1 372214.    83.5E 06                                          00002600
    262      1    1 804840.    49.9E 06                                          00002610
    263      8    3    5    3    1      1240.                           1000.    00002620
    264                                             35.0  E 06             -35.0E06 00002630
    265      0    1 198000.  -217.32E06                                          00002640
    266      1    1 409460.    50.5E 06                                          00002650
    267      1    1 965217.    37.0E 06                                          00002660
    268      8    3    5    2    1      1320.                           1000.    00002670
    269                                             27.2  E 06             -27.2E06 00002680
    270      0    1 148000.  -91.818E06                                          00002690
    271      1    1 662500.    31.8E 06                                          00002700
    272      9    3    5    3    1      1400.                           1000.    00002710
    273                                                                          00002720
    274      0    1 123500.  -54.998E06                                          00002730
    275      1    1 350720.    24.2E 06                                          00002740
    276      1    1 914520.    18.9E 06                                          00002750
    277  NONZERO ANGULAR MOMENTA (NHI CARDS):                                    00002760
    278  16          .1   E06                                                    00002770
    279  17          .1   E06                                                    00002780
    280  NONZERO MASS ORIENTATION ANGLES (NPH CARDS):                            00002790
    281     16     -.0872665  .0349066  .05236                                   00002800
    282     17     -.0872665  .0349066  .05236                                   00002810
    283  FORCE TIME HISTORY DATA: NACC + CARDS                                   00002820
    284      1    3    2    1                                                    00002830
    285      2    3    2    1                                                    00002840
    286      3    3    2    1                                                    00002850
    287      4    3    2    1                                                    00002860
    288      5    3    2    1                                                    00002870
    289      6    3    2    1                                                    00002880
    290      7    3    2    1                                                    00002890
    291      8    3    2    1                                                    00002900
    292      9    3    2    1                                                    00002910
    293     10    3    2    1                                                    00002920
    294     11    3    2    1                                                    00002930
    295     12    3    2    1                                                    00002940
    296     13    3    2    1                                                    00002950
    297     14    3    2    1                                                    00002960
    298     15    3    2    1                                                    00002970
    299     16    3    2    1                                                    00002980
    300     17    3    2    1                                                    00002990
    301     18    3    2    1                                                    00003000
    302     19    3    2    1                                                    00003010
    303     0.          -95.                                                     00003020
    304     1.         -95.                                                      00003030
    305     0.         -624.5                                                    00003040
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 6 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

   306    1.          -624.5                                                     00003050
   307    0.         -1861.                                                      00003060
   308    1.         -1861.                                                      00003070
   309    0.         -4715.                                                      00003080
   310    1.         -4715.                                                      00003090
   311    0.         -7901.                                                      00003100
   312    1.         -7901.                                                      00003110
   313    0.         -1991.                                                      00003120
   314    1.         -1991.                                                      00003130
   315    0.         -2316.                                                      00003140
   316    1.         -2316.                                                      00003150
   317    0.          -785.4                                                     00003160
   318    1.          -785.4                                                     00003170
   319    0.          -450.                                                      00003180
   320    1.          -450.0                                                     00003190
   321    0.         17445.6                                                     00003200
   322    1.         17445.6                                                     00003210
   323    0.        -15419.2                                                     00003220
   324    1.        -15419.2                                                     00003230
   325    0.        -28188.2                                                     00003240
   326    1.        -28188.2                                                     00003250
   327    0.        -21394.1                                                     00003260
   328    1.        -21394.1                                                     00003270
   329    0.        -17818.8                                                     00003280
   330    1.        -17818.8                                                     00003290
   331    0.         -6240.9                                                     00003300
   332    1.         -6240.9                                                     00003310
   333    0.          -270.8                                                     00003320
   334    1.          -270.8                                                     00003330
   335    0.          -258.3                                                     00003340
   336    1.          -258.3                                                     00003350
   337    0.             0.                                                      00003360
   338    1.             0.                                                      00003370
   339    0.             0.                                                      00003380
   340    1.             0.                                                      00003390
   341 BEAM LOAD PLOT PARAMETERS:  NBFP CARDS                                     00003400
   342        3    1    1    1    0                                              00003410
   343        7    1    1    1    1                                              00003420
   344       11    1    1    1    0                                              00003430
   345       11    1    1    1    1                                              00003440
   346       12    1    1    1    1                                              00003450
   347       14    1    1    1    0                                              00003460
   348 END                                                                       00003470
   349 $TITLE   =LT.SAMPLE.DATA                                                         1
   350 $SUBTITLE=21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL                2
   351 $LABEL   =INITIAL CONDITION STATIC SOLUTION                                      3
   352 $DISPLACEMENTS                                                                   4
   353 $REAL OUTPUT                                                                     5
   354 $SUBCASE ID =          1                                                         6
   355        100       G     -3.089143E-02     0.0             -9.927106E-01          7
   356 -CONT-                  0.0              -2.240265E-03      0.0                  8
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 7 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                   1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

CARD NO.						
357	200	G	-2.848941E-02	0.0	-7.668377E-01	9
358	-CONT-		0.0	-2.228401E-03	0.0	10
359	201	G	1.302763E-01	0.0	-8.132805E-01	11
360	-CONT-		0.0	-2.228401E-03	0.0	12
361	300	G	-7.956207E-03	0.0	-4.223564E-01	13
362	-CONT-		0.0	-2.016658E-03	0.0	14
363	400	G	-3.881566E-03	0.0	-1.467094E-01	15
364	-CONT-		0.0	-1.310210E-03	0.0	16
365	500	G	0.0	0.0	0.0	17
366	-CONT-		0.0	0.0	0.0	18
367	501	G	0.0	0.0	0.0	19
368	-CONT-		0.0	0.0	0.0	20
369	600	G	3.900044E-04	0.0	-1.395651E-01	21
370	-CONT-		0.0	1.905726E-03	0.0	22
371	700	G	-1.741045E-02	0.0	-3.224223E-01	23
372	-CONT-		0.0	2.646158E-03	0.0	24
373	800	G	1.960037E-02	0.0	-8.574680E-01	25
374	-CONT-		0.0	3.925510E-03	0.0	26
375	900	G	1.623369E-01	0.0	-1.646019E+00	27
376	-CONT-		0.0	5.791210E-03	0.0	28
377	1000	G	4.121330E-01	0.0	-2.947555E+00	29
378	-CONT-		0.0	6.380443E-03	0.0	30
379	1100	G	-2.376708E-02	-6.204829E-02	4.549811E-01	31
380	-CONT-		-6.692741E-03	-2.201437E-03	-5.605556E-04	32
381	1101	G	-1.923054E-02	-6.048076E-02	3.946611E-01	33
382	-CONT-		-6.692741E-03	-2.201437E-03	-5.605556E-04	34
383	1102	G	-1.296112E-02	-1.657883E-01	7.333756E-01	35
384	-CONT-		-6.692741E-03	-2.201437E-03	-5.605556E-04	36
385	1103	G	-1.296112E-02	-1.657883E-01	7.333756E-01	37
386	-CONT-		-6.692741E-03	-2.201437E-03	-5.605556E-04	38
387	1199	G	-9.159952E-02	0.0	5.671605E-01	39
388	-CONT-		0.0	-6.671570E-03	0.0	40
389	1200	G	-2.163103E-01	4.138300E-02	2.341778E+00	41
390	-CONT-		-1.306025E-02	-6.671570E-03	-9.325834E-04	42
391	1201	G	-2.439489E-01	3.842940E-02	2.721848E+00	43
392	-CONT-		-1.306025E-02	-6.671570E-03	-9.325834E-04	44
393	1300	G	-6.008096E-01	3.054580E-01	6.170235E+00	45
394	-CONT-		-2.241265E-02	-1.032134E-02	-1.681539E-03	46
395	1400	G	-1.368592E+00	6.399863E-01	1.084585E+01	47
396	-CONT-		-2.562700E-02	-7.394243E-03	-5.296096E-03	48
397	1401	G	-1.022668E+00	2.900483E-01	9.660551E+00	49
398	-CONT-		-2.562700E-02	-7.394243E-03	-5.296096E-03	50
399	1498	G	-6.724822E-01	0.0	8.267696E+00	51
400	-CONT-		0.0	-9.067804E-03	0.0	52
401	1499	G	-6.724822E-01	0.0	8.267696E+00	53
402	-CONT-		0.0	-9.067804E-03	0.0	54
403	1500	G	-2.495207E+00	4.342729E-01	1.459589E+01	55
404	-CONT-		-1.709940E-02	-9.067804E-03	-4.925180E-03	56
405	1501	G	-2.554651E+00	3.717276E-01	1.491743E+01	57
406	-CONT-		-1.709940E-02	-9.067804E-03	-4.925180E-03	58
407	1502	G	-2.495207E+00	4.342729E-01	1.459589E+01	59

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 8 OF 9)

ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

```
                   1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

  408   -CONT-                  -1.709940E-02     -9.067804E-03     -4.925180E-03       60
  409         1600       G       7.919735E-02     -2.893812E-01      1.937819E+00       61
  410   -CONT-                  -1.295901E-02     -9.379078E-03     -1.573280E-03       62
  411         1601       G      -2.385548E-01      1.247810E-01      2.086104E+00       63
  412   -CONT-                  -1.295901E-02     -9.379078E-03     -1.573280E-03       64
  413         1602       G       7.919735E-02     -2.893812E-01      1.937819E+00       65
  414   -CONT-                  -1.295901E-02     -9.379078E-03     -1.573280E-03       66
  415         1700       G      -6.952552E-01     -3.464461E-02      8.834676E+00       67
  416   -CONT-                  -2.537085E-02     -9.936552E-03     -5.952675E-03       68
  417         1701       G      -1.014152E+00      6.997874E-01      8.967885E+00       69
  418   -CONT-                  -2.537085E-02     -9.936552E-03     -5.952675E-03       70
  419         1800       G       1.832870E-01     -7.628592E-01      6.225001E-01       71
  420   -CONT-                  -6.689243E-03     -2.204068E-03     -5.605288E-04       72
  421         1900       G       2.696309E-01      0.0              -8.798568E-01       73
  422   -CONT-                   0.0              -2.223161E-03      0.0                74
  423         2000       G      -9.809875E-02      0.0              -8.621072E-01       75
  424   -CONT-                   0.0              -4.137885E-03      0.0                76
  425         2100       G      -7.305723E-02      0.0              -7.669372E-01       77
  426   -CONT-                   0.0              -2.228401E-03      0.0                78
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 9 OF 9)

LT.SAMPLE.DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

PROGRAM SIZE DATA

NUMBER OF:

MASSES	SPRINGS	BEAMS	KR TABLES	NON-ZERO HE OR IXY	MASS PENETR.	VOLUME CHANGE	DRI ELEMENTS	MTL TYPES	ACCEL. TABLES	NON-STANDARD MAX. DEFL. NVB +	NON-STANDARD MAX. DEFL. NVB -	NON-STANDARD MAX. FORCE NFB +	NON-STANDARD MAX. FORCE NFB -	NON-ZERO PHI''	NON-STANDARD DAMPING	STIFFNESS MATRICES	NO. NODE PTS.
NM	NSP	NB	NLB	NHI	MVP	NVCH	NDRI	NMTL	NACC	+	-	+	-	NPH	ND	NKM	NNP
21	19	28	1	2	0	0	1	0	19	0	0	2	2	21	0	0	12

NSC= 1 NIC= 1 NTOL1= 1000% NTOL2= 1000% NTOL3= 1000%

NO.OF OLEO STRUTS= 2 ALPHA= 1.000D 00

NAERO = 0 RHO = 1.14630D-07

ACCELERATION DATA TRANSFER CONTROL PARAMETERS

REUSE: TITLE -
CASE - 0
NO. TABLES - 0

SAVE: TITLE -
CASE - 0
NMSAV - 0
NNPSAV - 0
NDTSAV - 0
NWRFLG - 0
NDTGRA -

PROGRAM DATA MANAGEMENT CONTROL DATA

RESTART: TITLE -
CASE - 0
TIME - 0

SAVE: TITLE -
CASE - 0
TIMES - 0 0 0 0 0

VARIABLE INTEGRATION CONTROL DATA

VAR. INT. FLAG = 0 EL = 0.0 EU = 0.0 LOWER RATIO = 0.0 UPPER RATIO = 0.0

PROGRAM CONTROL DATA

PRINT INTERVAL/ INTEGRATION INTERVAL	INTEGRATION INTERVAL	MAX. TIME	PLOW FORCE STARTING TIME	FILTER CUTOFF FREQUENCY	CASE TYPE INDICATOR
DP/DT	DT	TMAX	PLOWT	FCUT	RUNMOD
200	0.000050	0.100000	0.0	50.000	1.000

TIME HISTORY PRINT CONTROL CARDS

STRAIN FORCES	TOTAL FORCES	BEAM DEFLECTIONS	EXT.SPRING DATA	ENERGY DATA	STRESS DATA	ACCEL DATA	IMPULSE DATA
1	1	1	1	1	0	1	0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 1 OF 16)

NO.MASS POSITION PLOTS

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

XGDOT P' PHI'	YGDOT Q' THETA'	ZGDOT R' PSI'
3.140000D 03	0.0	3.000000D 02
0.0	1.000000D-01	0.0
0.0	1.745000D-02	0.0

INITIAL MASS POINT DEFLECTIONS

I	DXAP(I)	DYAP(I)	DZAP(I)	DPHAP(I)	DTHAP(I)	DPSAP(I)	I
1	3.089143D-02	0.0	9.927106D-01	0.0	-2.240265D-03	0.0	1
2	2.848941D-02	0.0	7.668377D-01	0.0	-2.228401D-03	0.0	2
3	7.956207D-03	0.0	4.223564D-01	0.0	-2.016658D-03	0.0	3
4	3.881566D-03	0.0	1.467094D-01	0.0	-1.310210D-03	0.0	4
5	0.0	0.0	0.0	0.0	0.0	0.0	5
6	-3.900044D-04	0.0	1.395651D-01	0.0	1.905726D-03	0.0	6
7	1.741045D-02	0.0	3.224223D-01	0.0	2.646158D-03	0.0	7
8	-1.960037D-02	0.0	8.574680D-01	0.0	3.925510D-03	0.0	8
9	-1.623369D-01	0.0	1.646019D 00	0.0	5.791210D-03	0.0	9
10	-4.121330D-01	0.0	2.947555D 00	0.0	6.380443D-03	0.0	10
11	2.376708D-02	-6.204829D-02	-4.549811D-01	6.692741D-03	-2.201437D-03	5.605556D-04	11
12	2.183183D-01	4.138300D-02	-2.341778D 00	1.306025D-02	-6.671570D-03	9.325834D-04	12
13	6.008096D-01	3.054580D-01	-6.170235D 00	2.241265D-02	-1.032134D-02	1.681539D-03	13
14	1.368592D 00	6.399863D-01	-1.084585D 01	2.562700D-02	-7.394243D-03	5.296096D-03	14
15	2.495207D 00	4.342729D-01	-1.459589D 01	1.709940D-02	-9.067804D-03	4.925180D-03	15
16	-7.919735D-02	-2.893812D-01	-1.937819D 00	1.295901D-02	-9.379078D-03	1.573280D-03	16
17	6.952552D-01	-3.464461D-02	-8.834676D 00	2.537085D-02	-9.936552D-03	5.952675D-03	17
18	-1.832870D-01	-7.628592D-01	-6.225001D-01	6.689243D-03	-2.204068D-03	5.605288D-04	18
19	-2.696309D-01	0.0	8.798568D-01	0.0	-2.223161D-03	0.0	19
20	9.809875D-02	0.0	8.621072D-01	0.0	-4.137885D-03	0.0	20
21	7.305723D-02	0.0	7.669372D-01	0.0	-2.228401D-03	0.0	21

INITIAL NODE POINT DEFLECTIONS

I	M	DXNPAP	DYNPAP	DZNPAP
5	1	0.0	0.0	0.0
11	1	1.923054D-02	-6.048076D-02	-3.946611D-01
11	2	1.296112D-02	-1.657883D-01	-7.333756D-01
11	3	1.296112D-02	-1.657883D-01	-7.333756D-01
12	1	2.439489D-01	3.842940D-02	-2.721848D 00
14	1	1.022668D 00	2.900483D-01	-9.660551D 00
15	1	2.554651D 00	3.717276D-01	-1.491743D 01
15	2	2.495207D 00	4.342729D-01	-1.459589D 01
16	1	2.385548D-01	1.247810D-01	-2.086104D 00
16	2	-7.919735D-02	-2.893812D-01	-1.937819D 00
17	1	1.014152D 00	6.997874D-01	-8.967885D 00

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 2 OF 16)

2 1 -1.302763D-01 0.0 8.132805D-01

GENERALIZED SURFACE DATA

BETA = 0.0 DEGREES
XGIN = 0.0
ZGIN = 0.0

MASS DATA

	WEIGHTS	MASS COORDINATES F.S.,B.L.,W.L.			MASS MOMENTS OF INERTIA (LB-IN-SEC**2)			
I	W	X''	Y''	Z''	IX	IY	IZ	I
1	1.58500D 03	1.98969D 02	0.0	2.19007D 02	1.15140D 04	4.00000D 04	1.50000D 04	1
2	9.06450D 03	2.99972D 02	0.0	2.17933D 02	8.90800D 04	3.00000D 05	9.90000D 04	2
3	1.53181D 04	4.59992D 02	0.0	2.08278D 02	1.62780D 05	9.69350D 04	1.03090D 05	3
4	1.30960D 04	6.19996D 02	0.0	2.05853D 02	1.96270D 05	6.67150D 04	7.93890D 04	4
5	2.17526D 04	8.20000D 02	0.0	2.00200D 02	4.91060D 05	1.25670D 05	1.46510D 05	5
6	7.90150D 03	9.60000D 02	0.0	2.12260D 02	8.13830D 04	1.20000D 05	2.00000D 05	6
7	9.19070D 03	1.03998D 03	0.0	2.07578D 02	8.75360D 04	1.40000D 05	2.00000D 05	7
8	9.93840D 03	1.20002D 03	0.0	2.24243D 02	8.80980D 04	1.80000D 05	3.00000D 05	8
9	5.70200D 03	1.36006D 03	0.0	2.58354D 02	9.62490D 04	4.17880D 04	2.60390D 04	9
10	6.17520D 03	1.57041D 03	0.0	2.99352D 02	2.15300D 05	1.07980D 05	1.58630D 05	10
11	9.67060D 03	8.01276D 02	1.18362D 02	1.88755D 02	1.52130D 04	1.38580D 05	3.60000D 05	11
12	1.00656D 04	8.52082D 02	2.71759D 02	2.05442D 02	1.95100D 04	1.22630D 05	3.00000D 05	12
13	5.28650D 03	9.42899D 02	4.30395D 02	2.26070D 02	7.27150D 03	5.26190D 04	1.10000D 05	13
14	3.75900D 03	1.04443D 03	5.82860D 02	2.54346D 02	4.40830D 03	2.58230D 04	6.00000D 04	14
15	1.54230D 03	1.11010D 03	7.40166D 02	2.69696D 02	1.67080D 03	9.01370D 03	1.80000D 04	15
16	5.40000D 03	7.19079D 02	3.21889D 02	1.67738D 02	3.65156D 03	2.57460D 04	2.93746D 04	16
17	5.15100D 03	9.02105D 02	5.51635D 02	1.96935D 02	3.71200D 03	2.45882D 04	2.81780D 04	17
18	1.92200D 03	8.87183D 02	1.32363D 02	9.13225D 01	3.71000D 02	1.60000D 03	2.00000D 03	18
19	2.38000D 02	2.79270D 02	0.0	8.41201D 01	2.40000D 01	3.00000D 02	5.00000D 02	19
20	1.00000D 03	2.99902D 02	0.0	2.37838D 02	1.00000D 03	1.00000D 03	1.00000D 03	20
21	1.00000D 03	2.99927D 02	0.0	2.37933D 02	1.00000D 03	1.00000D 03	1.00000D 03	21

NODE POINT DATA

MASS	N.P.	NODE POINT COORDINATES F.S.,B.L.,W.L.		
I	M	X''	Y''	Z''
5	1	7.75100D 02	4.80000D 01	1.81000D 02
11	1	7.73881D 02	1.18360D 02	1.86695D 02
11	2	8.86987D 02	1.31766D 02	1.80433D 02
11	3	8.86987D 02	1.31766D 02	1.80433D 02
12	1	8.11556D 02	3.21562D 02	2.02322D 02
14	1	9.93477D 02	5.51310D 02	2.30161D 02
15	1	1.14545D 03	7.40228D 02	2.76217D 02
15	2	1.11010D 03	7.40166D 02	2.69696D 02
16	1	7.35461D 02	3.21475D 02	2.01686D 02
16	2	7.19079D 02	3.21889D 02	1.67738D 02
17	1	9.17386D 02	5.50900D 02	2.29468D 02
2	1	2.79130D 02	0.0	1.46687D 02

EXTERNAL SPRING DATA

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 3 OF 16)

SPRING I	K	M	FREE LENGTH LBAR(IKM)	FRICTION COEFFICIENT MU(IKM)	BOTTOMING SPRING KE(IKM)	PLOWING FORCE FORCE(IKM)	GROUND FLEXIBILITY GFLEX(IKM)
1	3	0	7.000000D 01	3.500000-01	1.750000 05	0.0	0.0
2	3	0	8.270000 01	3.500000-01	3.000000 05	0.0	0.0
3	3	0	7.270000 01	3.500000-01	1.000000 05	0.0	0.0
4	3	0	7.000000 01	3.500000-01	3.000000 05	0.0	0.0
5	3	0	6.420000 01	3.500000-01	3.000000 05	0.0	0.0
6	3	0	7.640000 01	3.500000-01	3.000000 05	0.0	0.0
7	3	0	6.990000 01	3.500000-01	1.000000 05	0.0	0.0
8	3	0	6.910000 01	3.500000-01	1.000000 05	0.0	0.0
9	3	0	6.400000 01	3.500000-01	3.000000 05	0.0	0.0
10	3	0	8.200000 01	3.500000-01	3.000000 05	0.0	0.0
11	3	0	2.800000 01	3.500000-01	1.000000 05	0.0	0.0
12	3	0	1.400000 01	3.500000-01	1.000000 05	0.0	0.0
13	3	0	1.100000 01	3.500000-01	1.000000 05	0.0	0.0
14	3	0	7.000000 00	3.500000-01	1.000000 05	0.0	0.0
15	3	0	3.000000 00	3.500000-01	1.000000 05	0.0	0.0
16	3	0	2.980000 01	3.500000-01	2.720000 05	0.0	0.0
17	3	0	2.800000 01	3.500000-01	2.720000 05	0.0	0.0
18	3	0	1.965000 01	3.000000-01	1.000000 05	0.0	0.0
19	3	0	1.645000 01	3.000000-01	1.000000 05	0.0	0.0

SPRING I	K	M	DEFLECTION COORDINATES SI(IKM)	SA(IKM)	SB(IKM)	SF(IKM)	SPRING AXIAL FORCES FSPOI(IKM)	FSPOF(IKM)	CRIT.DAMP	CDAMP(IKM)
1	3	0	1.300000 00	1.500000 00	1.600000 00	1.000000 01	7.000000 04	7.000000 03	0.0	0.0
2	3	0	1.300000 00	1.500000 00	1.600000 00	1.000000 01	1.400000 05	1.400000 04	0.0	0.0
3	3	0	1.000000 00	6.000000 00	1.000000 01	2.100000 01	1.150000 05	9.000000 04	0.0	0.0
4	3	0	1.000000 00	1.100000 00	2.000000 00	3.000000 00	3.400000 05	2.000000 05	0.0	0.0
5	3	0	1.000000 00	1.100000 00	2.000000 00	3.000000 00	3.400000 05	2.000000 05	0.0	0.0
6	3	0	1.000000 00	1.100000 00	2.000000 00	3.000000 00	3.400000 05	2.000000 05	0.0	0.0
7	3	0	1.000000 00	6.000000 00	1.000000 01	2.100000 01	6.000000 04	4.800000 04	0.0	0.0
8	3	0	1.000000 00	6.000000 00	1.000000 01	2.100000 01	6.800000 04	4.800000 04	0.0	0.0
9	3	0	1.000000 00	1.100000 00	2.000000 00	3.000000 00	3.000000 05	3.000000 04	0.0	0.0
10	3	0	1.000000 00	1.100000 00	2.000000 00	3.000000 00	3.000000 05	3.000000 04	0.0	0.0
11	3	0	1.000000 00	1.500000 00	2.000000 00	7.000000 00	3.300000 05	3.300000 05	0.0	0.0
12	3	0	1.000000 00	1.500000 00	2.000000 00	7.000000 00	3.300000 05	3.300000 05	0.0	0.0
13	3	0	1.000000 00	1.500000 00	2.000000 00	7.000000 00	3.300000 05	3.300000 05	0.0	0.0
14	3	0	1.000000 00	1.500000 00	2.000000 00	7.000000 00	3.300000 05	3.300000 05	0.0	0.0
15	3	0	1.000000 00	1.500000 00	2.000000 00	7.000000 00	3.300000 05	3.300000 05	0.0	0.0
16	3	0	1.000000 00	8.000000 00	9.000000 00	1.600000 01	1.000000 04	3.000000 04	0.0	0.0
17	3	0	1.000000 00	8.000000 00	9.000000 00	1.600000 01	1.000000 04	3.000000 04	0.0	0.0
18	3	0	2.000000 00	2.001000 00	8.050000 00	8.051000 00	6.220000 04	2.947000 05	2.000000-02	1.573250 01
19	3	0	2.000000 00	2.001000 00	5.750000 00	5.751000 00	1.615000 04	5.150000 04	2.000000-02	2.820990 00

MATERIAL PROPERTIES

MATERIAL NO.	MODULUS OF ELASTICITY	MODULUS OF RIGIDITY	TENSION STRESS	COMPRESS. STRESS	SHEAR STRESS
1	3.0000D 07	1.1000D 07	75000.	75000.	37500.
2	3.0000D 07	1.1000D 07	205000.	205000.	80000.
3	2.8000D 07	1.2500D 07	70000.	46000.	36000.
4	1.0500D 07	4.0000D 06	47000.	39000.	22000.
5	1.0000D 07	3.8000D 06	35000.	34000.	17000.
6	1.0000D 07	3.8000D 06	16000.	16000.	17000.

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 4 OF 16)

7	1.0000D 06	4.0000D 05	16000.	16000.	17000.
8	1.0000D 06	0.0	16000.	16000.	17000.
9	1.0000D 06	4.0000D 05	16000.	16000.	17000.
10	1.0000D 06	4.0000D 05	16000.	16000.	17000.

INTERNAL BEAM DATA

BEAM					AREA	MOMENTS OF INERTIA			DISTANCES FROM NEUTRAL AXIS TO EXTREME FIBRES ZBIJ AXIS	YBIJ AXIS	TORSION PARAMETER	LENGTH	DAMPING RATIO	MTL	P-CODES				VBM	BEAM NO.
IJ	I	J	M	N	A	IYY	IZZ	JX	Z1	Z2	XIQ	XLB	CBAR	MC	YI	ZI	YJ	ZJ	VBM	IJ
1	1	2	0	0	3.200D 01	6.200D 04	3.700D 04	9.900D 04	9.600D 01	9.600D 01	0.0	1.010D 02	5.000D-02	5	0	0	1	1	0	1
2	2	3	0	0	3.600D 01	7.700D 04	4.300D 04	1.200D 05	9.900D 01	9.900D 01	0.0	1.603D 02	5.000D-02	5	0	0	1	1	0	2
3	3	4	0	0	3.600D 01	8.600D 04	4.300D 04	1.290D 05	5.600D 01	5.600D 01	0.0	1.600D 02	5.000D-02	5	0	0	1	1	0	3
4	4	5	0	0	5.900D 01	1.360D 05	4.650D 04	1.825D 05	5.600D 01	5.600D 01	0.0	2.001D 02	5.000D-02	5	0	0	1	1	0	4
5	5	6	0	0	5.900D 01	1.160D 05	4.650D 04	1.625D 05	6.600D 01	6.600D 01	0.0	1.405D 02	5.000D-02	5	0	0	1	1	0	5
6	6	7	0	0	5.700D 01	1.360D 05	5.700D 04	1.930D 05	8.800D 01	8.800D 01	0.0	8.012D 01	5.000D-02	5	0	0	1	1	0	6
7	7	8	0	0	4.800D 01	1.140D 05	6.200D 04	1.760D 05	9.100D 01	9.100D 01	0.0	1.609D 02	5.000D-02	5	0	0	1	1	0	7
8	8	9	0	0	3.700D 01	5.600D 04	3.350D 04	8.950D 04	5.100D 01	5.100D 01	0.0	1.636D 02	5.000D-02	5	0	0	1	1	0	8
9	9	10	0	0	2.500D 01	9.000D 04	9.500D 03	9.950D 04	5.000D 01	5.000D 01	0.0	2.143D 02	5.000D-02	5	0	0	0	0	0	9
10	5	11	0	1	5.400D 01	1.590D 04	1.140D 05	4.800D 04	1.000D 00	1.000D 00	0.0	1.277D 02	5.000D-02	5	0	0	0	0	0	10
11	11	12	1	0	6.320D 01	1.140D 04	1.020D 05	2.600D 04	1.000D 00	1.000D 00	0.0	1.732D 02	5.000D-02	5	0	0	0	0	0	11
12	12	13	0	0	5.630D 01	4.700D 03	5.800D 04	1.000D 04	1.000D 00	1.000D 00	0.0	1.840D 02	5.000D-02	5	0	0	0	0	0	12
13	13	14	0	0	4.070D 01	2.000D 03	2.100D 04	4.800D 03	1.000D 00	1.000D 00	0.0	1.853D 02	5.000D-02	5	0	0	0	0	0	13
14	14	15	0	1	2.000D 01	1.200D 03	8.000D 03	2.700D 03	1.000D 00	1.000D 00	0.0	1.883D 02	5.000D-02	5	0	0	0	0	0	14
15	12	16	1	1	8.000D 00	7.320D 02	1.000D 02	2.208D 02	1.000D 00	1.000D 00	0.0	7.610D 01	5.000D-02	4	0	0	0	0	0	15
16	14	17	1	1	8.000D 00	7.320D 02	1.000D 02	2.208D 02	1.000D 00	1.000D 00	0.0	7.610D 01	5.000D-02	4	0	0	0	0	0	16
17	11	18	2	0	1.000D-02	2.390D 02	2.390D 02	1.500D 02	1.000D 00	1.000D 00	0.0	8.911D 01	5.000D-02	1	0	0	0	0	1	17
18	11	18	3	0	1.000D-02	2.390D 02	2.390D 02	1.500D 02	1.000D 00	1.000D 00	0.0	8.911D 01	5.000D-02	1	0	0	0	0	1	18
19	2	19	1	0	1.000D-02	3.250D 01	3.250D 01	5.000D 00	1.000D 00	1.000D 00	0.0	6.257D 01	5.000D-02	1	0	0	0	0	1	19
20	6	12	0	0	4.070D 01	2.000D 03	2.100D 04	4.800D 03	1.000D 00	1.000D 00	0.0	2.925D 02	5.000D-02	5	0	0	1	1	0	20
21	9	14	0	0	4.070D 01	2.000D 03	2.100D 04	4.800D 03	1.000D 00	1.000D 00	0.0	6.628D 02	5.000D-02	5	0	1	0	1	0	21
22	12	0	0	0	4.070D 01	2.000D 03	2.100D 04	4.800D 03	1.000D 00	1.000D 00	0.0	5.435D 02	5.000D-02	5	0	0	0	0	0	22
23	2	20	0	0	2.036D-01	1.000D 00	1.000D 00	1.000D 00	1.000D 00	1.000D 00	0.0	1.990D 01	3.161D-01	9	0	0	0	0	1	23
24	2	21	0	0	1.309D-01	1.000D 00	1.000D 00	1.000D 00	1.000D 00	1.000D 00	0.0	2.000D 01	2.318D-01	10	0	0	0	0	1	24
25	15	16	0	0	2.000D 01	0.0	0.0	0.0	1.000D 00	1.000D 00	0.0	5.816D 02	5.000D-02	5	0	0	0	0	0	25
26	15	16	2	2	2.000D 01	0.0	0.0	0.0	1.000D 00	1.000D 00	0.0	5.816D 02	5.000D-02	5	0	0	0	0	0	26
27	15	0	0	0	2.000D 01	1.200D 03	8.000D 03	2.700D 03	1.000D 00	1.000D 00	0.0	1.480D 03	5.000D-02	5	0	0	0	0	0	27
28	15	0	2	0	2.000D 01	1.200D 03	8.000D 03	2.700D 03	1.000D 00	1.000D 00	0.0	1.480D 03	5.000D-02	5	0	0	0	0	0	28

UNSYMMETRICAL BEAM DATA

BEAM					TENSION-COMPRESSION FLAG	DEADBAND
IJ	I	J	M	N	IJUB	DB
25	15	16	0	0	1	8.000D-02
26	15	16	2	2	-1	8.000D-02
27	15	0	0	0	1	3.000D-01
28	15	0	2	0	-1	3.000D-01

PLASTIC HINGE AND END-FIXITY DATA

BEAM	P-CODES	SHAPE FACTORS	PLASTIC HINGE MOMENTS

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 5 OF 16)

IJ	I	J	M	N	IYIZJYJZ	SF35	SF26	SF35J	SF26J	PLM35	PLM26	PLM35J	PLM26J
1	1	2	0	0	0 0 1 1	0.0	0.0	0.009	1.150	0.0	0.0	1.989D 05	1.551D 07
2	2	3	0	0	0 0 1 1	0.0	0.0	1.250	1.250	0.0	0.0	3.403D 07	1.900D 07
3	3	4	0	0	0 0 1 1	0.0	0.0	1.100	1.100	0.0	0.0	5.912D 07	2.956D 07
4	4	5	0	0	0 0 1 1	0.0	0.0	1.150	1.150	0.0	0.0	9.775D 07	3.342D 07
5	5	6	0	0	0 0 1 1	0.0	0.0	1.250	1.250	0.0	0.0	7.689D 07	3.082D 07
6	6	7	0	0	0 0 1 1	0.0	0.0	1.250	1.250	0.0	0.0	6.761D 07	2.834D 07
7	7	8	0	0	0 0 1 1	0.0	0.0	1.150	1.150	0.0	0.0	5.042D 07	2.742D 07
8	8	9	0	0	0 0 1 1	0.0	0.0	1.000	1.000	0.0	0.0	3.843D 07	2.299D 07
20	6	12	0	0	0 0 1 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	9	14	0	0	0 1 0 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OLEO STRUT BEAM DATA

BEAM AIR CURVE PARAMETERS

IJ	I	J	M	N	EOLEO	FAO	FAA	EXPOLE	YMAX
17	11	18	2	0	2.098D 01	1.086D 04	7.390D 02	1.400D 00	2.000D 01
19	2	19	1	0	1.697D 01	3.420D 03	2.890D 02	1.400D 00	1.600D 01

BEAM DAMPING CONSTANTS,COULOMB FRICTION AND LINEAR SPRINGS (EXTENSION&COMPRESSION)

IJ	I	J	M	N	BOLEO	BROLEO	XKEXT	XKCOMP	FCOUL	MPTAB
17	11	18	2	0	4.000D 00	0.0	1.000D 05	1.000D 05	5.000D 03	1
19	2	19	1	0	3.400D 00	0.0	5.000D 04	5.000D 04	5.000D 02	0

OLEO METERING PIN TABLES

TABLE NO. 1

YOLEO	BH
-2.00000D-01	3.52700D 02
-9.64000D-02	3.52700D 02
-3.76000D-02	1.02400D 01
1.24000D-01	2.36200D 01
3.41000D-01	2.22100D 01
6.07000D-01	1.79000D 01
9.53000D-01	8.24000D 00
1.46000D 00	3.38000D 00
2.17000D 00	2.13000D 00
3.07000D 00	1.25000D 00
4.13000D 00	1.56000D 00
5.21000D 00	1.79000D 00
6.20000D 00	2.46000D 00
7.05000D 00	3.58000D 00
7.72000D 00	6.26000D 00
8.20000D 00	1.34700D 01
8.53000D 00	3.15000D 01
8.74000D 00	6.24000D 01
8.91000D 00	6.40600D 01
9.12000D 00	3.42200D 01
9.41000D 00	1.60300D 01
9.83000D 00	8.42000D 00
1.03900D 01	5.24000D 00
1.10800D 01	3.68000D 00
1.18700D 01	2.93000D 00

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 6 OF 16)

1.[illegible]1000D 01	2.770000D 00
1.[illegible]400D 01	3.280000D 00
1.4[illegible]D 01	4.9[illegible]000D 00
1.4[illegible]000D 01	[illegible]0000D 00
1.5[illegible]1000D 01	[illegible]000D 01
1.540000D 01	1.[illegible]7900D 02
1.545180D 01	1.000000D 03
1.5[illegible]0D 01	1.000000D 03
1.545810D 01	1.000000D 03
1.549400D 01	4.038500D 02
1.561000D 01	6.770000D 01
1.564000D 01	2.215000D 01
1.618000D 01	9.930000D 00
1.665000D 01	5.310000D 00
1.721000D 01	3.020000D 00
1.782000D 01	2.070000D 00
1.839000D 01	9.200000D-01
1.882000D 01	0.0
1.897000D 01	1.000000D 01
2.200000D 01	1.000000D 01

NONLINEAR BEAM DATA

BEAM					DIRECTION	STANDARD TABLE NO.	LINEAR DEFLECTION	BOTTOMING DEFLECTION
IJ	I	J	M	N	L	NP	LDP	LDP1
18	11	18	3	0	1	7	2.00000E 00	0.0

KR TABLE FOR I,J,M,N,L = 11 18 3 0 1

1	0.0	1.00000E 00
2	2.00000E 00	1.00000E 00
3	2.00200E 00	-5.00000E-01
4	6.00000E 00	-5.00000E-01
5	6.00200E 00	0.0
6	2.00000E 01	0.0
7	4.00000E 01	0.0

DRI ELEMENTS

I	J
2	21

NON-STANDARD MAXIMUM POS & NEG FORCES

BEAM					MAXIMUM FORCES FMAX(IJ,L) L=					
IJ	I	J	M	N	1	2	3	4	5	6
1	1	2	0	0	0.0	0.0	0.0	0.0	0.0	0.0
					0.0	0.0	0.0	0.0	0.0	0.0
2	2	3	0	0	0.0	0.0	0.0	0.0	0.0	0.0
					0.0	0.0	0.0	0.0	0.0	0.0
3	3	4	0	0	0.0	0.0	0.0	0.0	0.0	0.0
					0.0	0.0	0.0	0.0	0.0	0.0
4	4	5	0	0	0.0	0.0	0.0	0.0	0.0	0.0
					0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 7 OF 16)

```
 5  5  6  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
 6  6  7  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
 7  7  8  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
 8  8  9  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
 9  9 10  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
10  5 11  0  1  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
11 11 12  1  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
12 12 13  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
13 13 14  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
14 14 15  0  1  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
15 12 16  1  1  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
16 14 17  1  1  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
17 11 18  2  0  4.2800D 05   0.0          0.0          0.0          0.0          0.0
                4.2800D 05   0.0          0.0          0.0          0.0          0.0
18 11 18  3  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
19  2 19  1  0  1.3000D 05   0.0          7.8000D 04   0.0          0.0          0.0
                1.3000D 05   0.0          7.8000D 04   0.0          0.0          0.0
20  6 12  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
21  9 14  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
22 12  0  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
23  2 20  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
24  2 21  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
25 15 16  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
26 15 16  2  2  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
27 15  0  0  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0
28 15  0  2  0  0.0          0.0          0.0          0.0          0.0          0.0
                0.0          0.0          0.0          0.0          0.0          0.0

LOAD INTERACTION CURVE SIGN CONVENTION VECTORS

SIGN            CALAC LOAD NUMBER AND SIGN
CONVENTION      FOR USER LOAD NUMBER =
NUMBER            1    2    3    4    5    6

   1              1    2   -3    4    5    6

LOAD INTERACTION CURVE DATA
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 8 OF 16)

CURVE NO.	BEAM NO.	LOAD NUMBER FOR X AXIS	LOAD NUMBER FOR Y AXIS	NO. OF SLOPING INTERACTION LINES	SIGN CONVEN-TION NUMBER	INTERACTION CURVE LOCATION FS	BL	WL	RUPTURE RATIO
1	1	3	5	4	0	300.0000	0.0	0.0	1000.0000
2	2	3	5	4	0	300.0000	0.0	0.0	1000.0000
3	2	3	5	8	0	400.0000	0.0	0.0	1000.0000
4	3	3	5	8	0	480.0000	0.0	0.0	1000.0000
5	3	3	5	8	0	540.0000	0.0	0.0	1000.0000
6	3	3	5	8	0	620.0000	0.0	0.0	1000.0000
7	4	3	5	8	0	620.0000	0.0	0.0	1000.0000
8	5	3	5	6	1	960.0000	0.0	0.0	1000.0000
9	6	3	5	6	1	960.0000	0.0	0.0	1000.0000
10	6	3	5	8	1	1000.0000	0.0	0.0	1000.0000
11	7	3	5	10	1	1080.0000	0.0	0.0	1000.0000
12	7	3	5	10	1	1160.0000	0.0	0.0	1000.0000
13	8	3	5	10	1	1240.0000	0.0	0.0	1000.0000
14	8	3	5	6	1	1320.0000	0.0	0.0	1000.0000
15	9	3	5	10	1	1400.0000	0.0	0.0	1000.0000

CURVE NO.	MAXIMUM LOAD CUTOFFS: +X AXIS	+Y AXIS	-X AXIS	-Y AXIS	LOAD LINE INTERCEPTS X AXIS	Y AXIS	LOAD LINE NUMBER
1	1.6600D 05	2.0800D 07	-1.6600D 05	-2.0800D 07	1.9900D 05	4.5600D 07	1
					1.9900D 05	-4.5600D 07	2
					-1.9900D 05	4.5600D 07	3
					-1.9900D 05	-4.5600D 07	4
2	1.6600D 05	2.0800D 07	-1.6600D 05	-2.0800D 07	1.9900D 05	4.5600D 07	1
					1.9900D 05	-4.5600D 07	2
					-1.9900D 05	4.5600D 07	3
					-1.9900D 05	-4.5600D 07	4
3	2.1000D 05	2.3800D 07	-2.1000D 05	-2.3800D 07	1.8500D 05	6.0800D 07	1
					6.7430D 05	2.5400D 07	2
					1.8500D 05	-6.0800D 07	3
					-1.8500D 05	6.0800D 07	4
					-1.8500D 05	-6.0800D 07	5
					6.7430D 05	-2.5400D 07	6
					-6.7430D 05	2.5400D 07	7
					-6.7430D 05	-2.5400D 07	8
4	1.0000D 20	1.0000D 20	1.0000D 20	1.0000D 20	1.9500D 05	1.3030D 08	1
					5.4530D 05	2.8900D 07	2
					1.9500D 05	-1.3030D 08	3
					-1.9500D 05	1.3030D 08	4
					-1.9500D 05	-1.3030D 08	5
					5.4530D 05	-2.8900D 07	6
					-5.4530D 05	2.8900D 07	7
					-5.4530D 05	-2.8900D 07	8
5	1.0000D 20	1.0000D 20	1.0000D 20	1.0000D 20	1.9900D 05	1.3730D 08	1
					1.3654D 06	3.5300D 07	2
					1.9900D 05	-1.3730D 08	3
					-1.9900D 05	1.3730D 08	4
					-1.9900D 05	-1.3730D 08	5
					1.3654D 06	-3.5300D 07	6
					-1.3654D 06	3.5300D 07	7
					-1.3654D 06	-3.5300D 07	8
6	2.7400D 05	4.5000D 07	-2.7400D 05	-4.5000D 07	2.8600D 05	1.8560D 08	1
					3.8440D 05	7.9700D 07	2
					2.8600D 05	-1.8560D 08	3
					-2.8600D 05	1.8560D 08	4
					-2.8600D 05	-1.8560D 08	5
					3.8440D 05	-7.9700D 07	6

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 9 OF 16)

					-3.8440D 05	7.9700D 07	7
					-3.8440D 05	-7.9700D 07	8
7	2.7400D 05	4.5000D 07	-2.7400D 05	-4.5000D 07	2.8600D 05	1.8560D 08	1
					3.8440D 05	7.9700D 07	2
					2.8600D 05	-1.8560D 08	3
					-2.8600D 05	1.8560D 08	4
					-2.8600D 05	-1.8560D 08	5
					3.8440D 05	-7.9700D 07	6
					-3.8440D 05	7.9700D 07	7
					-3.8440D 05	-7.9700D 07	8
8	2.8800D 05	1.0000D 20	-2.8800D 05	1.0000D 20	-5.2317D 06	7.1500D 07	1
					4.7450D 05	1.5280D 08	2
					-5.2317D 06	-7.1500D 07	3
					4.7450D 05	-1.5280D 08	4
					-4.7450D 05	1.5280D 08	5
					-4.7450D 05	-1.5280D 08	6
9	2.8800D 05	1.0000D 20	-2.8800D 05	1.0000D 20	-5.2317D 06	7.1500D 07	1
					4.7450D 05	1.5280D 08	2
					-5.2317D 06	-7.1500D 07	3
					4.7450D 05	-1.5280D 08	4
					-4.7450D 05	1.5280D 08	5
					-4.7450D 05	-1.5280D 08	6
10	2.5400D 05	7.4000D 07	-2.5400D 05	-7.4000D 07	3.0100D 05	2.2870D 08	1
					1.3581D 06	8.4200D 07	2
					3.0100D 05	-2.2870D 08	3
					-3.0100D 05	2.2870D 08	4
					-3.0100D 05	-2.2870D 08	5
					1.3581D 06	-8.4200D 07	6
					-1.3581D 06	8.4200D 07	7
					-1.3581D 06	-8.4200D 07	8
11	1.0000D 20	1.0000D 20	1.0000D 20	1.0000D 20	2.1000D 05	-5.5588D 08	1
					3.2770D 05	1.0775D 08	2
					1.5738D 06	6.4000D 07	3
					-2.1000D 05	-5.5588D 08	4
					3.2770D 05	-1.0775D 08	5
					-3.2770D 05	1.0775D 08	6
					-3.2770D 05	-1.0775D 08	7
					1.5738D 06	-6.4000D 07	8
					-1.5738D 06	6.4000D 07	9
					-1.5738D 06	-6.4000D 07	10
12	1.0000D 20	1.0000D 20	1.0000D 20	1.0000D 20	2.3900D 05	-2.6564D 08	1
					3.7221D 05	8.3500D 07	2
					8.0484D 05	4.9900D 07	3
					-2.3900D 05	-2.6564D 08	4
					3.7221D 05	-8.3500D 07	5
					-3.7221D 05	8.3500D 07	6
					-3.7221D 05	-8.3500D 07	7
					8.0484D 05	-4.9900D 07	8
					-8.0484D 05	4.9900D 07	9
					-8.0484D 05	-4.9900D 07	10
13	1.0000D 20	3.5000D 07	1.0000D 20	-3.5000D 07	1.9800D 05	-2.1732D 08	1
					4.0946D 05	5.0500D 07	2
					9.6522D 05	3.7000D 07	3
					-1.9800D 05	-2.1732D 08	4
					4.0946D 05	-5.0500D 07	5
					-4.0946D 05	5.0500D 07	6
					-4.0946D 05	-5.0500D 07	7
					9.6522D 05	-3.7000D 07	8
					-9.6522D 05	3.7000D 07	9
					-9.6522D 05	-3.7000D 07	10

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 10 OF 16)

14	1.0000D 20	2.7200D 07	1.0000D 20	-2.7200D 07	1.4800D 05	-9.1818D 07	1
					6.6250D 05	3.1800D 07	2
					-1.4800D 05	-9.1818D 07	3
					6.6250D 05	-3.1800D 07	4
					-6.6250D 05	3.1800D 07	5
					-6.6250D 05	-3.1800D 07	6
15	1.0000D 20	1.0000D 20	1.0000D 20	1.0000D 20	1.2350D 05	-5.4998D 07	1
					3.5072D 05	2.4200D 07	2
					9.1452D 05	1.8900D 07	3
					-1.2350D 05	-5.4998D 07	4
					3.5072D 05	-2.4200D 07	5
					-3.5072D 05	2.4200D 07	6
					-3.5072D 05	-2.4200D 07	7
					9.1452D 05	-1.8900D 07	8
					-9.1452D 05	1.8900D 07	9
					-9.1452D 05	-1.8900D 07	10

MASSES HAVING NONZERO ANGULAR MOMENTA (HE),
CROSS PRODUCTS OF INERTIA (IXY,IYZ,IXZ)
OR LIFT CONSTANTS (LC)

I	LC	HEX	HEY	HEZ	IXY	IYZ	IXZ
16	0.0	1.0000D 05	0.0	0.0	0.0	0.0	0.0
17	0.0	1.0000D 05	0.0	0.0	0.0	0.0	0.0

NONZERO PHIDP,THEDP,PSIDP

I	PHIDP	THEDP	PSIDP
1	0.0	-2.24027D-03	0.0
2	0.0	-2.22840D-03	0.0
3	0.0	-2.01666D-03	0.0
4	0.0	-1.31021D-03	0.0
5	0.0	0.0	0.0
6	0.0	1.90573D-03	0.0
7	0.0	2.64616D-03	0.0
8	0.0	3.92551D-03	0.0
9	0.0	5.79121D-03	0.0
10	0.0	6.38044D-03	0.0
11	6.69274D-03	-2.20144D-03	5.60556D-04
12	1.30603D-02	-6.67157D-03	9.32583D-04
13	2.24127D-02	-1.03213D-02	1.68154D-03
14	2.56270D-02	-7.39424D-03	5.29610D-03
15	1.70994D-02	-9.06780D-03	4.92518D-03
16	-7.48129D-02	2.48595D-02	5.43662D-02
17	-6.24449D-02	2.36452D-02	5.91654D-02
18	6.68924D-03	-2.20407D-03	5.60529D-04
19	0.0	-2.22316D-03	0.0
20	0.0	-4.13788D-03	0.0
21	0.0	-2.22840D-03	0.0

ACCELERATION INPUT TABLE DATA

MASS LOCATION	DIRECTION		TYPE
1	3		1
2	[illegible]	2	1
3	3	2	1
4	3	2	1
5	3	2	1
6	3	2	1

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 11 OF 16)

7	3	2	1
8	3	2	1
9	3	2	1
10	3	2	1
11	3	2	1
12	3	2	1
13	3	2	1
14	3	2	1
15	3	2	1
16	3	2	1
17	3	2	1
18	3	2	1
19	3	2	1

PT	TIME	ACCEL
1	0.0	-9.500E 01
2	1.000E 00	-9.500E 01
3	0.0	-6.245E 02
4	1.000E 00	-6.245E 02
5	0.0	-1.861E 03
6	1.000E 00	-1.861E 03
7	0.0	-4.715E 03
8	1.000E 00	-4.715E 03
9	0.0	-7.901E 03
10	1.000E 00	-7.901E 03
11	0.0	-1.991E 03
12	1.000E 00	-1.991E 03
13	0.0	-2.316E 03
14	1.000E 00	-2.316E 03
15	0.0	-7.854E 02
16	1.000E 00	-7.854E 02
17	0.0	-4.500E 02
18	1.000E 00	-4.500E 02
19	0.0	1.745E 04
20	1.000E 00	1.745E 04
21	0.0	-1.542E 04
22	1.000E 00	-1.542E 04
23	0.0	-2.819E 04
24	1.000E 00	-2.819E 04
25	0.0	-2.139E 04
26	1.000E 00	-2.139E 04
27	0.0	-1.782E 04
28	1.000E 00	-1.782E 04
29	0.0	-6.241E 03
30	1.000E 00	-6.241E 03
31	0.0	-2.708E 02
32	1.000E 00	-2.708E 02
33	0.0	-2.583E 02
34	1.000E 00	-2.583E 02
35	0.0	0.0
36	1.000E 00	0.0
37	0.0	0.0
38	1.000E 00	0.0

```
I,J,M,N
K-MATRIX FOR INTERNAL BEAM IJ
  1  2  0  0
    3.16806D 06    0.0         0.0         0.0         0.0         0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 12 OF 16)

```
 0.0          4.30838D 06  0.0          0.0          0.0          -2.17591D 08
 0.0          0.0          7.21945D 06  0.0          3.64612D 08   0.0
 0.0          0.0          0.0          3.72445D 09  0.0           0.0
 0.0          0.0          3.64612D 08  0.0          2.45525D 10   0.0
 0.0         -2.17591D 08  0.0          0.0          0.0           1.46523D 10
2  3  0  0
 2.24563D 06  0.0          0.0          0.0          0.0           0.0
 0.0          1.25243D 06  0.0          0.0          0.0          -1.00390D 08
 0.0          0.0          2.24273D 06  0.0          1.79768D 08   0.0
 0.0          0.0          0.0          2.84446D 09  0.0           0.0
 0.0          0.0          1.79768D 08  0.0          1.92126D 10   0.0
 0.0         -1.00390D 08  0.0          0.0          0.0           1.07291D 10
3  4  0  0
 2.24968D 06  0.0          0.0          0.0          0.0           0.0
 0.0          1.25924D 06  0.0          0.0          0.0          -1.00753D 08
 0.0          0.0          2.51847D 06  0.0          2.01506D 08   0.0
 0.0          0.0          0.0          3.06332D 09  0.0           0.0
 0.0          0.0          2.01506D 08  0.0          2.14970D 10   0.0
 0.0         -1.00753D 08  0.0          0.0          0.0           1.07485D 10
4  5  0  0
 2.94877D 06  0.0          0.0          0.0          0.0           0.0
 0.0          6.96624D 05  0.0          0.0          0.0          -6.96916D 07
 0.0          0.0          2.03744D 06  0.0          2.03829D 08   0.0
 0.0          0.0          0.0          3.46605D 09  0.0           0.0
 0.0          0.0          2.03829D 08  0.0          2.71886D 10   0.0
 0.0         -6.96916D 07  0.0          0.0          0.0           9.29611D 09
5  6  0  0
 4.19872D 06  0.0          0.0          0.0          0.0           0.0
 0.0          2.01108D 06  0.0          0.0          0.0          -1.41298D 08
 0.0          0.0          5.01689D 06  0.0          3.52484D 08   0.0
 0.0          0.0          0.0          4.39443D 09  0.0           0.0
 0.0          0.0          3.52484D 08  0.0          3.30205D 10   0.0
 0.0         -1.41298D 08  0.0          0.0          0.0           1.32367D 10
6  7  0  0
 7.11440D 06  0.0          0.0          0.0          0.0           0.0
 0.0          1.32999D 07  0.0          0.0          0.0          -5.32787D 08
 0.0          0.0          3.17330D 07  0.0          1.27121D 09   0.0
 0.0          0.0          0.0          9.15386D 09  0.0           0.0
 0.0          0.0          1.27121D 09  0.0          6.78989D 10   0.0
 0.0         -5.32787D 08  0.0          0.0          0.0           2.84576D 10
7  8  0  0
 2.98318D 06  0.0          0.0          0.0          0.0           0.0
 0.0          1.78602D 06  0.0          0.0          0.0          -1.43687D 08
 0.0          0.0          3.28397D 06  0.0          2.64199D 08   0.0
 0.0          0.0          0.0          4.15656D 09  0.0           0.0
 0.0          0.0          2.64199D 08  0.0          2.83402D 10   0.0
 0.0         -1.43687D 08  0.0          0.0          0.0           1.54131D 10
8  9  0  0
 2.26109D 06  0.0          0.0          0.0          0.0           0.0
 0.0          9.17438D 05  0.0          0.0          0.0          -7.50637D 07
 0.0          0.0          1.53363D 06  0.0          1.25480D 08   0.0
 0.0          0.0          0.0          2.07837D 09  0.0           0.0
 0.0          0.0          1.25480D 08  0.0          1.36888D 10   0.0
 0.0         -7.50637D 07  0.0          0.0          0.0           8.18883D 09
9 10  0  0
 1.16655D 06  0.0          0.0          0.0          0.0           0.0
 0.0          1.15822D 05  0.0          0.0          0.0          -1.24108D 07
 0.0          0.0          1.09726D 06  0.0          1.17576D 08   0.0
 0.0          0.0          0.0          1.76428D 09  0.0           0.0
 0.0          0.0          1.17576D 08  0.0          1.67983D 10   0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 13 OF 16)

```
    0.0          -1.241080 07    0.0           0.0           0.0           1.773150 09
 5 11  0  1
    4.227200 06   0.0            0.0           0.0           0.0           0.0
    0.0           6.562400 06    0.0           0.0           0.0          -4.191540 08
    0.0           0.0            9.152820 05   0.0           5.846100 07   0.0
    0.0           0.0            0.0           1.427850 09   0.0           0.0
    0.0           0.0            5.846100 07   0.0           4.978700 09   0.0
    0.0          -4.191540 08    0.0           0.0           0.0           3.569630 10
11 12  1  0
    3.648990 06   0.0            0.0           0.0           0.0           0.0
    0.0           2.355850 06    0.0           0.0           0.0          -2.040150 08
    0.0           0.0            2.633000 05   0.0           2.280170 07   0.0
    0.0           0.0            0.0           5.704430 08   0.0           0.0
    0.0           0.0            2.280170 07   0.0           2.632810 09   0.0
    0.0          -2.040150 08    0.0           0.0           0.0           2.355670 10
12 13  0  0
    3.060560 06   0.0            0.0           0.0           0.0           0.0
    0.0           1.118120 06    0.0           0.0           0.0          -1.028410 08
    0.0           0.0            9.060630 04   0.0           8.333650 06   0.0
    0.0           0.0            0.0           2.065740 08   0.0           0.0
    0.0           0.0            8.333650 06   0.0           1.022000 09   0.0
    0.0          -1.028410 08    0.0           0.0           0.0           1.261190 10
13 14  0  0
    2.195860 06   0.0            0.0           0.0           0.0           0.0
    0.0           3.957620 05    0.0           0.0           0.0          -3.667690 07
    0.0           0.0            3.769160 04   0.0           3.493040 06   0.0
    0.0           0.0            0.0           9.840930 07   0.0           0.0
    0.0           0.0            3.493040 06   0.0           4.316200 08   0.0
    0.0          -3.667690 07    0.0           0.0           0.0           4.532010 09
14 15  0  1
    1.062280 06   0.0            0.0           0.0           0.0           0.0
    0.0           1.438480 05    0.0           0.0           0.0          -1.354140 07
    0.0           0.0            2.157720 04   0.0           2.031200 06   0.0
    0.0           0.0            0.0           5.449520 07   0.0           0.0
    0.0           0.0            2.031200 06   0.0           2.549480 08   0.0
    0.0          -1.354140 07    0.0           0.0           0.0           1.699650 09
12 16  1  1
    1.103850 06   0.0            0.0           0.0           0.0           0.0
    0.0           2.859320 04    0.0           0.0           0.0          -1.087930 06
    0.0           0.0            2.093020 05   0.0           7.963670 06   0.0
    0.0           0.0            0.0           1.160620 07   0.0           0.0
    0.0           0.0            7.963670 06   0.0           4.040090 08   0.0
    0.0          -1.087930 06    0.0           0.0           0.0           5.519250 07
14 17  1  1
    1.103870 06   0.0            0.0           0.0           0.0           0.0
    0.0           2.859500 04    0.0           0.0           0.0          -1.087980 06
    0.0           0.0            2.093150 05   0.0           7.963990 06   0.0
    0.0           0.0            0.0           1.160640 07   0.0           0.0
    0.0           0.0            7.963990 06   0.0           4.040170 08   0.0
    0.0          -1.087980 06    0.0           0.0           0.0           5.519360 07
11 18  2  0
    3.366510 03   0.0            0.0           0.0           0.0           0.0
    0.0           1.215840 05    0.0           0.0           0.0          -5.417360 06
    0.0           0.0            1.215840 05   0.0           5.417360 06   0.0
    0.0           0.0            0.0           1.851580 07   0.0           0.0
    0.0           0.0            5.417360 06   0.0           3.218380 08   0.0
    0.0          -5.417360 06    0.0           0.0           0.0           3.218380 08
11 18  3  0
    3.366510 03   0.0            0.0           0.0           0.0           0.0
    0.0           1.215840 05    0.0           0.0           0.0          -5.417360 06
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 14 OF 16)

```
   0.0            0.0            1.21584D 05    0.0            5.41736D 06    0.0
   0.0            0.0            0.0            1.85158D 07    0.0            0.0
   0.0            0.0            5.41736D 06    0.0            3.21838D 08    0.0
   0.0           -5.41736D 06    0.0            0.0            0.0            3.21838D 08
 2 19  1  0
   4.79488D 03    0.0            0.0            0.0            0.0            0.0
   0.0            4.77700D 04    0.0            0.0            0.0           -1.49441D 06
   0.0            0.0            4.77700D 04    0.0            1.49441D 06    0.0
   0.0            0.0            0.0            8.79061D 05    0.0            0.0
   0.0            0.0            1.49441D 06    0.0            6.23334D 07    0.0
   0.0           -1.49441D 06    0.0            0.0            0.0            6.23334D 07
 6 12  0  0
   1.39154D 06    0.0            0.0            0.0            0.0            0.0
   0.0            1.00717D 05    0.0            0.0            0.0           -1.47290D 07
   0.0            0.0            9.59211D 03    0.0            1.40276D 06    0.0
   0.0            0.0            0.0            6.23628D 07    0.0            0.0
   0.0            0.0            1.40276D 06    0.0            2.73521D 08    0.0
   0.0           -1.47290D 07    0.0            0.0            0.0            2.87197D 09
 9 14  0  0
   6.14019D 05    0.0            0.0            0.0            0.0            0.0
   0.0            8.65292D 03    0.0            0.0            0.0           -2.86778D 06
   0.0            0.0            8.24088D 02    0.0            2.73122D 05    0.0
   0.0            0.0            0.0            2.75177D 07    0.0            0.0
   0.0            0.0            2.73122D 05    0.0            1.20692D 08    0.0
   0.0           -2.86778D 06    0.0            0.0            0.0            1.26726D 09
12  0  0  0
   7.48826D 05    0.0            0.0            0.0            0.0            0.0
   0.0            1.56950D 04    0.0            0.0            0.0           -4.26524D 06
   0.0            0.0            1.49476D 03    0.0            4.06214D 05    0.0
   0.0            0.0            0.0            3.35592D 07    0.0            0.0
   0.0            0.0            4.06214D 05    0.0            1.47189D 08    0.0
   0.0           -4.26524D 06    0.0            0.0            0.0            1.54549D 09
 2 20  0  0
   1.02276D 04    0.0            0.0            0.0            0.0            0.0
   0.0            1.52161D 03    0.0            0.0            0.0           -1.51437D 04
   0.0            0.0            1.52161D 03    0.0            1.51437D 04    0.0
   0.0            0.0            0.0            2.00956D 04    0.0            0.0
   0.0            0.0            1.51437D 04    0.0            2.00956D 05    0.0
   0.0           -1.51437D 04    0.0            0.0            0.0            2.00956D 05
 2 21  0  0
   6.54560D 03    0.0            0.0            0.0            0.0            0.0
   0.0            1.50001D 03    0.0            0.0            0.0           -1.50001D 04
   0.0            0.0            1.50001D 03    0.0            1.50001D 04    0.0
   0.0            0.0            0.0            2.00000D 04    0.0            0.0
   0.0            0.0            1.50001D 04    0.0            2.00000D 05    0.0
   0.0           -1.50001D 04    0.0            0.0            0.0            2.00000D 05
15 16  0  0
   3.43883D 05    0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
15 16  2  2
   3.43883D 05    0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
   0.0            0.0            0.0            0.0            0.0            0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 15 OF 16)

```
15  0  0  0
  1.351050 05    0.0            0.0            0.0            0.0            0.0
  0.0            2.959340 02    0.0            0.0            0.0           -2.190400 05
  0.0            0.0            4.439000 01    0.0            3.285600 04    0.0
  0.0            0.0            0.0            6.930880 06    0.0            0.0
  0.0            0.0            3.285600 04    0.0            3.242520 07    0.0
  0.0           -2.190400 05    0.0            0.0            0.0            2.161680 08
15  0  2  0
  1.351050 05    0.0            0.0            0.0            0.0            0.0
  0.0            2.959340 02    0.0            0.0            0.0           -2.190400 05
  0.0            0.0            4.439000 01    0.0            3.285600 04    0.0
  0.0            0.0            0.0            6.930880 06    0.0            0.0
  0.0            0.0            3.285600 04    0.0            3.242520 07    0.0
  0.0           -2.190400 05    0.0            0.0            0.0            2.161680 08
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 16 OF 16)

- Nonzero mass orientation Euler angles (optional) (When a static deflection data set XYZ.NASOUT.DATA is read in, all masses will be rotated and a complete printout of this section of data will occur.)

- Acceleration input table data (optional)

- $\left[K_{ij}\right]$ matrices for all NB internal beams

The nonlinear beam data section prints out all the KR tables, whether these are user-input or standard tables coded into KRASH85. Similarly, the 6×6 linear stiffness matrix $\left[K_{ij}\right]$ is printed for all NB internal beam elements, whether $\left[K_{ij}\right]$ is directly input by the user or internally calculated in KRASH. The printed matrix corresponds to the lower right-hand quandrant of a full 12 by 12 beam stiffness matrix (figure 1-19, Vol. 1).

Certain items in this formatted printout of the input data provide additional information not directly input by the user. These include the following:

- External spring data - The actual damping constant used in the KRASH85 calculations of spring damping force is shown (CDAMP(IKM)).

- Internal beam data - Beam lengths are shown (XLB). The item called VBM is a flag denoting which, if any, of the beams the program treats as vertical beams. VBM = 1 corresponds to a vertical beam, and VBM = 0 corresponds to a normal beam. The interpretation of the beam orientation Euler angles, part of the time-history beam deflection output, depends upon whether a normal or vertical beam is noted.

- Plastic hinge and end-fixity data - The actual plastic hinge moments, calculated within the program, are output. (PLM35,...,PLM26J)

- Mass data - The coordinates for the mass and node points are not equal to those input by the user in XYZ.DATA. The input coordinates have been modified by the initial mass and node point deflections, also shown in the formatted output of the input data. All calculations in KRASH85 use the modified coordinate data.

2.3.1.3 Miscellaneous Calculated Data

The miscellaneous calculated data are illustrated in figure 2-10, and is described in the following subsections.

2.3.1.3.1 Model Parameters. - The overall vehicle weight, c.g. position, and inertias are shown. These are used to see how well the anlytical model matches the actual vehicle being analyzed. This output is always for a complete airplane, even if only a half-airplane model is input (RUMMOD = 1.0). The initial position of the vehicle c.g., relative to the ground, is also shown.

2.3.1.3.2 Beam Loads and Deflections Corresponding to Yielding. - This output is generated only if NIC on card 50 (figure 2-3) is input nonzero. The beam loads and deflections corresponding to yielding are used as guidelines for establishing nonlinear deflection points for internal beam KR curves. The loads are calculated using the stress and buckling equations discussed in Volume I, Section 1.3.17, along with the appropriate yield stress for the beam material given in table 2-3 of this report.

The loads corresponding to yield stress are uncoupled loads (e.g., the shear forces are those corresonding to yielding without any bending moment applied.) Similarly, beam deflections are those resulting from the corresponding load only without the coupled load being applied. In actual loading situations, some degree of coupling is always present, so the deflections corresponding to yield provide only a rough indication of appropriate values to use for setting up KR curves. Furthermore, no attempt has been made to include in the analysis the effects of stress concentrations, geometric shape factors, and end attachment details.

2.3.1.3.3 Overall Vehicle Forces/Accelerations at Time Zero. - This block of output data is printed twice. The first time shows the six net loads (pounds and inch-pounds) at the airplane c.g., and the resulting six rigid body accelerations. These c.g. accelerations are then used to calculate the rigid body acceleration at each mass point in the model. These mass point accelerations yield inertia relief loads at each mass point. If these inertia relief loads are included in the total airplane force/moment balance, the net c.g. loads and accelerations should be zero. The second printout shows that the c.g. loads/accelerations, including inertia relief, are indeed very small (less than E-16 for all accelerations). The above calculations are performed in

subroutine NETFOR, the purpose of which is to calculate the net forces acting on each mass. These forces are used in the NASTRAN static load solution. Inertia relief loads are included to guarantee that a balanced set of applied loads is input to the NASTRAN model.

2.3.1.3.4 <u>Individual Mass Forces Accelerations At Time Zero</u>. - Figure 2-10 also shows this list of loads and accelerations for each mass in the model. The specific data output for each mass is as follows:

Line 1: Gravity loads, c.g. axes

Line 2: External loads, c.g. axes. These are the loads due to input time histories of external loads at specified masses, per the 3500-series cards. This is the method used to input aerodynamic loads into the model for the sample case.

Line 3: Aerodynamic lift, c.g. axes. These data reflects any aerodynamic lift calculated by means of inputting LC on the 3100-series cards. This option is not used in the sample case. The aerodynamic loads calculated using the 3300-series aero data are not included in the load calculations in NETFOR. Therefore, these loads will not get into the NASTRAN model to determine the proper balanced initial conditions.

Line 4: Inertia loads, c.g. axes. The inertia loads are calculated in NETFOR, as described in Section 2.3.1.4 above, to achieve a balanced set of loads for input to NASTRAN.

Line 5: Net loads, c.g. axes. These loads are the sum of all the above loads. The net loads are the input to the NASTRAN static load solution.

Line 6: Accelerations, mass axes. These are the rigid body airplane accelerations at time zero at each mass point. As explained in Section 2.3.1.4, these accelerations are calculated from the airplane c.g. acceleration, which in turn is calculated from all the loads except inertia relief loads. The mass point accelerations in line 6 times the mass point inertia matrix yields the inertia relief loads. These accelerations are output in mass axes to facilitate comparisons with KRASH85 time-history output at time zero. The accelerations for the latter are also in mass axes. The two sets of accelerations should be equal for a properly balanced set of initial conditions.

All quantities shown in this output have the units of pounds or inch-pounds for loads, and g's or rad/sec^2 for accelerations. The sign convention

is positive forward, right, and down, with right-hand moments about those axes. These data are presented basically as reference information; the user need not examine these data closely. The determination of whether or not the balanced initial conditions are acceptably accurate can be made based on data that are presented at the time zero printout from program KRASH85. (Section 2.3.3).

2.3.2 MSCTRAN Output

The output data from MSC/NASTRAN are discussed in this section. Familiarity with these output data is not necessary to successfully run program KRASH. If difficulties occur in achieving a balanced initial condition, then a review of this data may be necessary to help isolate the problem.

2.3.2.1 Executive Control Deck Echo

This is shown in figure 2-11, and consists of only four lines. These are generated automatically by program KRASHIC. SOL 24 refers to Rigid Format Solution No. 24, which is the small deflection linear static solution.

2.3.2.2 Case Control Deck Echo

This is also shown in figure 2-11, and contains only 13 cards. These are generated automatically by program KRASHIC. The output control card DISPLACEMENT (PRINT,PUNCH) = ALL, used in conjunction with the appropriate JCL cards, causes the output displacement vector to be written as data set XYZ.NASOUT.DATA in the user's library. If the user wants to eliminate or revise some of the NASTRAN output data, then Format No. 1020 in subroutine NAST, in program KRASHIC, should be revised accordingly.

2.3.2.3 Input Bulk Data Deck Echo

The complete input bulk data deck is reproduced in this echo, shown as figure 2-12. All these cards are generated automatically by program KRASHIC, in subroutines NAST and NAST10. The CONM2 (mass property), PLOTEL (plot data) and EIGR (eigenvalue) cards are not used in the static load solution employed (SOL 24). KRASHIC converts a KRASH85 input data set into a NASTRAN

MODEL PARAMETERS

VEHICLE WT = 1.865560D 05

VEHICLE CG POSITION
X (FS) = 8.431390 02
Y (BL) = 0.0
Z (WL) = 2.094230 02

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) = 3.392920 07
I(YY) = 3.879550 07
I(ZZ) = 7.125540 07
I(XY) = 0.0
I(YZ) = 0.0
I(XZ) = 1.950610 06

VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG = 0.0
ZCG = -1.38499D 02

BEAM LOADS

	BEAM					AXIAL LOAD		SHEAR FORCE			MOMENT			BEAM			
IJ	I	J	M	N	BUCKLING	TENSION	COMPRESSION	LATERAL(Y)	VERTICAL(Z)	ROLL(X)	PITCH(Y)	YAW(Z)	IJ	I	J	M	N
1	1	2	0	0	7.1584D 08	1.1200D 06	1.0880D 06	3.6448D 05	3.6448D 05	0.0	2.1958D 07	1.3104D 07	1	1	2	0	0
2	2	3	0	0	3.3027D 08	1.2600D 06	1.2240D 06	4.1004D 05	4.1004D 05	0.0	2.6444D 07	1.4768D 07	2	2	3	0	0
3	3	4	0	0	3.3146D 08	1.2600D 06	1.2240D 06	4.1004D 05	4.1004D 05	0.0	5.2214D 07	2.6107D 07	3	3	4	0	0
4	4	5	0	0	2.2928D 08	2.0650D 06	2.0060D 06	6.7201D 05	6.7201D 05	0.0	8.2571D 07	2.8232D 07	4	4	5	0	0
5	5	6	0	0	4.6485D 08	2.0650D 06	2.0060D 06	6.7201D 05	6.7201D 05	0.0	5.9758D 07	2.3955D 07	5	5	6	0	0
6	6	7	0	0	1.7528D 09	1.9950D 06	1.9380D 06	6.4923D 05	6.4923D 05	0.0	5.2545D 07	2.2023D 07	6	6	7	0	0
7	7	8	0	0	4.7271D 08	1.6800D 06	1.6320D 06	5.4672D 05	5.4672D 05	0.0	4.2593D 07	2.3165D 07	7	7	8	0	0
8	8	9	0	0	2.4695D 08	1.2950D 06	1.2580D 06	4.2143D 05	4.2143D 05	0.0	3.7333D 07	2.2333D 07	8	8	9	0	0
9	9	10	0	0	8.1659D 07	8.7500D 05	8.5000D 05	2.8475D 05	2.8475D 05	0.0	6.1200D 07	6.4600D 06	9	9	10	0	0
10	5	11	0	1	3.8466D 08	1.8900D 06	1.8360D 06	6.1506D 05	6.1506D 05	0.0	5.4060D 08	3.8760D 09	10	5	11	0	1
11	11	12	1	0	1.5003D 08	2.2120D 06	2.1488D 06	7.1985D 05	7.1985D 05	0.0	3.8760D 08	3.4680D 09	11	11	12	1	0
12	12	13	0	0	5.4833D 07	1.9705D 06	1.9142D 06	6.4126D 05	6.4126D 05	0.0	1.5980D 08	1.9720D 09	12	12	13	0	0
13	13	14	0	0	2.2983D 07	1.4245D 06	1.3838D 06	4.6357D 05	4.6357D 05	0.0	6.8000D 07	7.1400D 08	13	13	14	0	0
14	14	15	0	1	1.3365D 07	7.0000D 05	6.8000D 05	2.2780D 05	2.2780D 05	0.0	4.0800D 07	2.7200D 08	14	14	15	0	1
15	12	16	1	1	7.1583D 06	3.7600D 05	3.1200D 05	1.1792D 05	1.1792D 05	0.0	2.8548D 07	3.9000D 06	15	12	16	1	1
16	14	17	1	1	7.1586D 06	3.7600D 05	3.1200D 05	1.1792D 05	1.1792D 05	0.0	2.8548D 07	3.9000D 06	16	14	17	1	1
17	11	18	2	0	3.5645D 07	7.5000D 02	7.5000D 02	2.5125D 02	2.5125D 02	0.0	1.7925D 07	1.7925D 07	17	11	18	2	0
18	11	18	3	0	3.5645D 07	7.5000D 02	7.5000D 02	2.5125D 02	2.5125D 02	0.0	1.7925D 07	1.7925D 07	18	11	18	3	0
19	2	19	1	0	9.8328D 06	7.5000D 02	7.5000D 02	2.5125D 02	2.5125D 02	0.0	2.4375D 06	2.4375D 06	19	2	19	1	0
20	6	12	0	0	4.6149D 06	1.4245D 06	1.3838D 06	4.6357D 05	4.6357D 05	0.0	6.8000D 07	7.1400D 08	20	6	12	0	0
21	9	14	0	0	1.7971D 06	1.4245D 06	1.3838D 06	0.0	4.6357D 05	0.0	6.8000D 07	0.0	21	9	14	0	0
22	12	0	0	0	2.6728D 06	1.4245D 06	1.3838D 06	4.6357D 05	4.6357D 05	0.0	6.8000D 07	7.1400D 08	22	12	0	0	0
23	2	20	0	0	9.9642D 04	3.2573D 03	3.2573D 03	2.3188D 03	2.3188D 03	0.0	1.6000D 04	1.6000D 04	23	2	20	0	0
24	2	21	0	0	9.8697D 04	2.0946D 03	2.0946D 03	1.4911D 03	1.4911D 03	0.0	1.6000D 04	1.6000D 04	24	2	21	0	0
25	15	16	0	0	0.0	7.0000D 05	6.8000D 05	2.2780D 05	2.2780D 05	0.0	0.0	0.0	25	15	16	0	0
26	15	16	2	2	0.0	7.0000D 05	6.8000D 05	2.2780D 05	2.2780D 05	0.0	0.0	0.0	26	15	16	2	2
27	15	0	0	0	2.1618D 05	7.0000D 05	6.8000D 05	2.2780D 05	2.2780D 05	0.0	4.0800D 07	2.7200D 08	27	15	0	0	0
28	15	0	2	0	2.1618D 05	7.0000D 05	6.8000D 05	2.2780D 05	2.2780D 05	0.0	4.0800D 07	2.7200D 08	28	15	0	2	0

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 1 OF 5)

BEAM DEFLECTIONS

IJ	BEAM I	BEAM J	M	N	DEFLECTION BUCKLING	DEFLECTION TENSION	DEFLECTION COMPRESSION	TRANSLATION DUE TO F(Y)	TRANSLATION DUE TO F(Z)	TRANSLATION DUE TO BM(Z)	BM(Y)	ROTATION ABOUT X-AXIS	ROTATION ABOUT Y-AXIS	ROTATION ABOUT Z-AXIS
1	1	2	0	0	2.260D 02	3.535D-01	3.434D-01	8.460D-02	5.049D-02	1.204D-01	1.204D-01	0.0	3.577D-03	3.577D-03
2	2	3	0	0	1.471D 02	5.611D-01	5.451D-01	3.274D-01	1.828D-01	2.942D-01	2.942D-01	0.0	5.506D-03	5.506D-03
3	3	4	0	0	1.473D 02	5.601D-01	5.441D-01	3.256D-01	1.628D-01	5.182D-01	5.182D-01	0.0	9.716D-03	9.716D-03
4	4	5	0	0	7.775D 01	7.003D-01	6.803D-01	9.647D-01	3.298D-01	8.102D-01	8.102D-01	0.0	1.215D-02	1.215D-02
5	5	6	0	0	1.107D 02	4.918D-01	4.778D-01	3.342D-01	1.339D-01	3.391D-01	3.391D-01	0.0	7.239D-03	7.239D-03
6	6	7	0	0	2.464D 02	2.804D-01	2.724D-01	4.881D-02	2.046D-02	8.267D-02	8.267D-02	0.0	3.096D-03	3.096D-03
7	7	8	0	0	1.585D 02	5.632D-01	5.471D-01	3.061D-01	1.665D-01	3.224D-01	3.224D-01	0.0	6.012D-03	6.012D-03
8	8	9	0	0	1.092D 02	5.727D-01	5.564D-01	4.594D-01	2.748D-01	5.951D-01	5.951D-01	0.0	1.091D-02	1.091D-02
9	9	10	0	0	7.000D 01	7.501D-01	7.286D-01	2.459D 00	2.595D-01	1.041D 00	1.041D 00	0.0	1.457D-02	1.457D-02
10	5	11	0	1	9.100D 01	4.471D-01	4.343D-01	9.372D-02	6.720D-01	1.849D 01	1.849D 01	0.0	4.343D-01	4.343D-01
11	11	12	1	0	4.112D 01	6.062D-01	5.889D-01	3.056D-01	2.734D 00	3.400D 01	3.400D 01	0.0	5.889D-01	5.889D-01
12	12	13	0	0	1.792D 01	6.438D-01	6.254D-01	5.735D-01	7.077D 00	3.835D 01	3.835D 01	0.0	6.254D-01	6.254D-01
13	13	14	0	0	1.047D 01	6.487D-01	6.302D-01	1.171D 00	1.230D 01	3.893D 01	3.893D 01	0.0	6.302D-01	6.302D-01
14	14	15	0	1	1.258D 01	6.590D-01	6.401D-01	1.584D 00	1.056D 01	4.017D 01	4.017D 01	0.0	6.401D-01	6.401D-01
15	12	16	1	1	6.485D 00	3.406D-01	2.826D-01	4.124D 00	5.634D-01	7.170D 00	7.170D 00	0.0	2.826D-01	2.826D-01
16	14	17	1	1	6.485D 00	3.406D-01	2.826D-01	4.124D 00	5.634D-01	7.169D 00	7.169D 00	0.0	2.826D-01	2.826D-01
17	11	18	2	0	1.059D 04	2.228D-01	2.228D-01	2.066D-03	2.066D-03	6.618D 00	6.618D 00	0.0	2.228D-01	2.228D-01
18	11	18	3	0	1.059D 04	2.228D-01	2.228D-01	2.066D-03	2.066D-03	6.618D 00	6.618D 00	0.0	2.228D-01	2.228D-01
19	2	19	1	0	2.051D 03	1.564D-01	1.564D-01	5.260D-03	5.260D-03	3.262D 00	3.262D 00	0.0	1.564D-01	1.564D-01
20	6	12	0	0	3.316D 00	1.024D 00	9.944D-01	4.603D 00	4.833D 01	9.695D 01	9.695D 01	0.0	9.944D-01	9.944D-01
21	9	14	0	0	2.927D 00	2.320D 00	2.254D 00	5.357D 01	5.625D 02	4.979D 02	4.979D 02	0.0	2.254D 00	2.254D 00
22	12	0	0	0	3.569D 00	1.902D 00	1.848D 00	2.954D 01	3.101D 02	3.348D 02	3.348D 02	0.0	1.848D 00	1.848D 00
23	2	20	0	0	9.742D 00	3.185D-01	3.185D-01	1.524D 00	1.524D 00	2.113D 00	2.113D 00	0.0	3.185D-01	3.185D-01
24	2	21	0	0	1.508D 01	3.200D-01	3.200D-01	9.940D-01	9.940D-01	2.133D 00	2.133D 00	0.0	3.200D-01	3.200D-01
25	15	16	0	0	0.0	2.036D 00	1.977D 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	15	16	2	2	0.0	2.036D 00	1.977D 00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	15	0	0	0	1.600D 00	5.181D 00	5.033D 00	7.698D 02	5.132D 03	2.484D 03	2.484D 03	0.0	5.033D 00	5.033D 00
28	15	0	2	0	1.600D 00	5.181D 00	5.033D 00	7.698D 02	5.132D 03	2.484D 03	2.484D 03	0.0	5.033D 00	5.033D 00

OVERALL VEHICLE FORCES AND ACCELS(G-S), A/P AXES

FX=	-1.91571D 03	AX=	-1.02688D-02
FY=	0.0	AY=	0.0
FZ=	4.09109D 03	AZ=	2.19296D-02
MX=	0.0	PDT=	0.0
MY=	-1.45248D 05	QDT=	-3.74394D-03
MZ=	0.0	RDT=	0.0

OVERALL VEHICLE FORCES AND ACCELS(G-S), INCLUDING INERTIA RELIEF, A/P AXES

FX=	-1.72529D-13	AX=	-9.24809D-19
FY=	0.0	AY=	0.0
FZ=	5.11591D-12	AZ=	2.74229D-17
MX=	0.0	PDT=	0.0
MY=	8.29459D-10	QDT=	2.13803D-17
MZ=	0.0	RDT=	0.0

INDIVIDUAL MASS FORCES/MOMENTS AND ACCELS
GRAVITY/EXTERNAL/LIFT/INERTIA/NET/ACCELS(G-S)

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 2 OF 5)

ACCELS IN MASS AXES, ALL OTHERS IN A/P AXES

MASS	X	Y	Z	L	M	N
1	-2.76568D 01	0.0	1.58476D 03	0.0	0.0	0.0
	2.12825D-01	0.0	-9.49998D 01	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	4.25797D 01	0.0	-4.50550D 01	0.0	1.49758D 02	0.0
	1.51357D 01	0.0	1.44470D 03	0.0	1.49758D 02	0.0
	-2.68004D-02	0.0	2.84860D-02	0.0	-3.74394D-03	0.0
2	-1.58167D 02	0.0	9.06312D 03	0.0	0.0	0.0
	1.39164D 00	0.0	-6.24498D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	2.19886D 02	0.0	-2.48534D 02	0.0	1.12318D 03	0.0
	6.31105D 01	0.0	8.19009D 03	0.0	1.12318D 03	0.0
	-2.41968D-02	0.0	2.74724D-02	0.0	-3.74394D-03	0.0
3	-2.67287D 02	0.0	1.53158D 04	0.0	0.0	0.0
	3.75300D 00	0.0	-1.86100D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	3.09518D 02	0.0	-3.92391D 02	0.0	3.62919D 02	0.0
	4.59834D 01	0.0	1.30624D 04	0.0	3.62919D 02	0.0
	-2.01543D-02	0.0	2.56569D-02	0.0	-3.74394D-03	0.0
4	-2.28514D 02	0.0	1.30940D 04	0.0	0.0	0.0
	6.17764D 00	0.0	-4.71500D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	2.10641D 02	0.0	-3.14323D 02	0.0	2.49777D 02	0.0
	-1.16955D 01	0.0	8.06469D 03	0.0	2.49777D 02	0.0
	-1.60529D-02	0.0	2.40225D-02	0.0	-3.74394D-03	0.0
5	-3.79564D 02	0.0	2.17493D 04	0.0	0.0	0.0
	0.0	0.0	-7.90100D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	2.38359D 02	0.0	-4.76710D 02	0.0	4.70501D 02	0.0
	-1.41205D 02	0.0	1.33716D 04	0.0	4.70501D 02	0.0
	-1.09577D-02	0.0	2.19151D-02	0.0	-3.74394D-03	0.0
6	-1.37874D 02	0.0	7.90030D 03	0.0	0.0	0.0
	-3.79430D 00	0.0	-1.99100D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	5.69998D 01	0.0	-1.64901D 02	0.0	4.49273D 02	0.0
	-8.46687D 01	0.0	5.74440D 03	0.0	4.49273D 02	0.0
	-7.25355D-03	0.0	2.08558D-02	0.0	-3.74394D-03	0.0
7	-1.60370D 02	0.0	9.18930D 03	0.0	0.0	0.0
	-6.12849D 00	0.0	-2.31599D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	4.76734D 01	0.0	-1.83561D 02	0.0	5.24152D 02	0.0
	-1.18825D 02	0.0	6.68975D 03	0.0	5.24152D 02	0.0
	-5.23997D-03	0.0	1.99587D-02	0.0	-3.74394D-03	0.0
8	-1.73416D 02	0.0	9.93689D 03	0.0	0.0	0.0
	-3.08309D 00	0.0	-7.85394D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	8.74043D 00	0.0	-1.87359D 02	0.0	6.73910D 02	0.0
	-1.67759D 02	0.0	8.96413D 03	0.0	6.73910D 02	0.0
	-9.53457D-04	0.0	1.88484D-02	0.0	-3.74394D-03	0.0

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 3 OF 5)

9	-9.94949D 01	0.0	5.70113D 03	0.0	0.0	0.0
	-2.60603D 00	0.0	-4.49992D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	-2.05134D 01	0.0	-1.03682D 02	0.0	1.56452D 02	0.0
	-1.22614D 02	0.0	5.14746D 03	0.0	1.56452D 02	0.0
	3.49222D-03	0.0	1.82039D-02	0.0	-3.74394D-03	0.0
10	-1.07752D 02	0.0	6.17426D 03	0.0	0.0	0.0
	1.11310D 02	0.0	1.74452D 04	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	-5.83230D 01	0.0	-1.06246D 02	0.0	4.04271D 02	0.0
	-5.47649D 01	0.0	2.35133D 04	0.0	4.04271D 02	0.0
	9.33475D-03	0.0	1.72652D-02	0.0	-3.74394D-03	0.0
11	-1.68743D 02	0.0	9.66913D 03	0.0	0.0	0.0
	3.38858D 01	1.03215D 02	-1.54188D 04	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	1.11732D 02	0.0	-2.10821D 02	1.45761D 01	5.18873D 02	-6.20855D 00
	-2.31254D 01	1.03215D 02	-5.96051D 03	1.45761D 01	5.18873D 02	-6.20855D 00
	-1.15058D-02	1.52548D-04	2.18250D-02	-2.09868D-06	-3.74386D-03	2.50617D-05
12	-1.75636D 02	0.0	1.00641D 04	0.0	0.0	0.0
	1.87699D 02	3.68310D 02	-2.81852D 04	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	1.01418D 02	0.0	-2.18823D 02	2.28770D 01	4.59233D 02	-9.48550D 00
	1.13481D 02	3.68310D 02	-1.83399D 04	2.28770D 01	4.59233D 02	-9.48550D 00
	-9.93049D-03	2.94185D-04	2.18044D-02	-3.49146D-06	-3.74362D-03	4.89187D-05
13	-9.22447D 01	0.0	5.28570D 03	0.0	0.0	0.0
	2.19950D 02	4.79829D 02	-2.13876D 04	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	3.97697D 01	0.0	-1.13095D 02	1.26375D 01	1.97110D 02	-5.44988D 00
	1.67475D 02	4.79829D 02	-1.62150D 04	1.26375D 01	1.97110D 02	-5.44988D 00
	-7.30167D-03	4.93800D-04	2.14641D-02	-6.29525D-06	-3.74300D-03	8.39695D-05
14	-6.55912D 01	0.0	3.75843D 03	0.0	0.0	0.0
	1.29292D 02	4.57283D 02	-1.78125D 04	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	1.73600D 01	0.0	-7.94689D 01	8.37535D 00	9.67618D 01	-4.35614D 00
	8.10609D 01	4.57283D 02	-1.41335D 04	8.37535D 00	9.67618D 01	-4.35614D 00
	-4.46175D-03	5.67031D-04	2.11670D-02	-1.98276D-05	-3.74266D-03	9.60807D-05
15	-2.69118D 01	0.0	1.54207D 03	0.0	0.0	0.0
	5.60559D 01	1.06988D 02	-6.23973D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	4.26908D 00	0.0	-3.22366D 01	1.41331D 00	3.37560D 01	-9.25661D-01
	3.34132D 01	1.06988D 02	-4.72990D 03	1.41331D 00	3.37560D 01	-9.25661D-01
	-2.57832D-03	3.71434D-04	2.09226D-02	-1.84388D-05	-3.74335D-03	6.41825D-05
16	-9.42252D 01	0.0	5.39918D 03	0.0	0.0	0.0
	-5.60265D 00	-2.05753D 01	-2.69959D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	7.49904D 01	0.0	-1.19086D 02	2.41058D 02	9.62259D 01	9.97136D 03
	-2.48374D 01	-2.05753D 01	5.01013D 03	2.41058D 02	9.62259D 01	9.97136D 03
	-1.44105D-02	-8.69527D-04	2.16971D-02	-2.03381D-04	-3.72758D-03	-2.84463D-04
17	-8.98804D 01	0.0	5.15022D 03	0.0	0.0	0.0
	-5.13129D 00	-1.64512D 01	-2.57724D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	4.56499D 01	0.0	-1.08347D 02	2.29263D 02	9.18382D 01	9.96840D 03

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 4 OF 5)

	-4.93618D 01	-1.64512D 01	4.78414D 03	2.29263D 02	9.18382D 01	9.96840D 03
	-9.34166D-03	-7.76184D-04	2.08112D-02	-2.21321D-04	-3.72978D-03	-2.38453D-04
18	-3.35372D 01	0.0	1.92171D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	1.97452D 01	0.0	-3.54470D 01	2.42191D-02	5.99037D 00	-1.68548D-02
	-1.37920D 01	0.0	1.88626D 03	2.42191D-02	5.99037D 00	-1.68548D-02
	-1.02326D-02	1.29277D-04	1.84649D-02	-2.09858D-06	-3.74386D-03	2.50486D-05
19	-4.15289D 00	0.0	2.37964D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	6.20994D 00	0.0	-5.74830D 00	0.0	1.12318D 00	0.0
	2.05705D 00	0.0	2.32215D 02	0.0	1.12318D 00	0.0
	-2.60384D-02	0.0	2.42105D-02	0.0	-3.74394D-03	0.0
20	-1.74491D 01	0.0	9.99848D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	2.40667D 01	0.0	-2.79347D 01	0.0	3.74394D 00	0.0
	6.61759D 00	0.0	9.71913D 02	0.0	3.74394D 00	0.0
	-2.39509D-02	0.0	2.80341D-02	0.0	-3.74394D-03	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 5 OF 5)

```
                                                   AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     1

   N A S T R A N   E X E C U T I V E   C O N T R O L   D E C K   E C H O


  ID MAGAMON,D7612
  SOL 24
  DIAG 8
  CEND

*** USER WARNING MESSAGE 4519, A TIME CARD IS MISSING. DEFAULT TIME LIMIT IS ONE MINUTE.
```

FIGURE 2-11. MSC/NASTRAN EXECUTIVE AND CASE CONTROL DECKS (SHEET 1 OF 2)

```
LT.SAMPLE.DATA
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL          AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    2

 INITIAL CONDITION STATIC SOLUTION

                                  C A S E    C O N T R O L   D E C K   E C H O
           CARD
           COUNT
             1        TITLE=LT.SAMPLE.DATA
             2        SUBTITLE=21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
             3        LABEL=INITIAL CONDITION STATIC SOLUTION
             4        LOAD=10
             5        ECHO=BOTH
             6        OUTPUT
             7            DISPLACEMENT(PRINT,PUNCH)=ALL
             8            SPCFORCES=ALL
             9            ELFORCE=ALL
            10            GPFORCE=ALL
            11            ESE=ALL
            12            OLOAD=ALL
            13        BEGIN BULK
```

FIGURE 2-11. MSC/NASTRAN EXECUTIVE AND CASE CONTROL DECKS (SHEET 2 OF 2)

```
LT.SAMPLE.DATA                                                              AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     3
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                        I N P U T   B U L K   D A T A   D E C K   E C H O

                    .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                    $
                    $     KRASH MASS POINTS CONVERTED TO NASTRAN GRID CARDS
                    $
                    GRID*           100                             198.9691085700  0.0            *   100G
                    *   100G  219.0072894000                                   246
                    GRID*           200                             299.9715105900  0.0            *   200G
                    *   200G  217.9331623000                                   246
                    GRID*           300                             459.9920437930  0.0            *   300G
                    *   300G  208.2776436000                                   246
                    GRID*           400                             619.9961184340  0.0            *   400G
                    *   400G  205.8532906000                                   246
                    GRID*           500                             820.0000000000  0.0            *   500G
                    *   500G  200.2000000000                                123456
                    GRID*           600                             960.0003900044  0.0            *   600G
                    *   600G  212.2604349000                                   246
                    GRID*           700                            1039.9825895500  0.0            *   700G
                    *   700G  207.5775777000                                   246
                    GRID*           800                            1200.0196003700  0.0            *   800G
                    *   800G  224.2425320000                                   246
                    GRID*           900                            1360.0623369000  0.0            *   900G
                    *   900G  258.3539810000                                   246
                    GRID*          1000                            1570.4121330000  0.0            *  1000G
                    *  1000G  299.3524450000                                   246
                    GRID*          1100                             801.2762329200 -118.3620482900*  1100G
                    *  1100G  188.7549811000                                     0
                    GRID*          1200                             852.0816817000 -271.7586170000*  1200G
                    *  1200G  205.4417780000                                     0
                    GRID*          1300                             942.8991904000 -430.3945420000*  1300G
                    *  1300G  226.0702350000                                     0
                    GRID*          1400                            1044.4314080000 -582.8600137000*  1400G
                    *  1400G  254.3458500000                                     0
                    GRID*          1500                            1110.1047930000 -740.1657271000*  1500G
                    *  1500G  269.6958900000                                     0
                    GRID*          1600                             719.0791973500 -321.8893812000*  1600G
                    *  1600G  167.7378190000                                     0
                    GRID*          1700                             902.1047448000 -551.6346446100*  1700G
                    *  1700G  196.9346760000                                     0
                    GRID*          1800                             887.1832870000 -132.3628592000*  1800G
                    *  1800G   91.3225001000                                     0
                    GRID*          1900                             279.2696309000  0.0            *  1900G
                    *  1900G   84.1201432000                                   246
                    GRID*          2000                             299.9019012500  0.0            *  2000G
                    *  2000G  237.8378928000                                   246
                    GRID*          2100                             299.9269427700  0.0            *  2100G
                    *  2100G  237.9330628000                                     0
                    $
                    $     KRASH MASSLESS NODE POINTS CONVERTED TO NASTRAN GRIDS
                    $
                    GRID*           501                             775.1000000000  -48.0000000000*   501G
                    *   501G  181.0000000000                                     0
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 1 OF 11)

```
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

                    I N P U T   B U L K   D A T A   D E C K   E C H O

 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
GRID*          1101                           773.8807694600 -118.3604807600*  1101G
*  1101G  186.6946611000                                   0
GRID*          1102                           886.9870388800 -131.7657883000*  1102G
*  1102G  180.4333756000                                   0
GRID*          1103                           886.9870388800 -131.7657883000*  1103G
*  1103G  180.4333756000                                   0
GRID*          1201                           811.5560511000 -321.5615706000*  1201G
*  1201G  202.3218480000                                   0
GRID*          1401                           993.4773320000 -551.3099517000*  1401G
*  1401G  230.1605510000                                   0
GRID*          1501                          1145.4453490000 -740.2282724000*  1501G
*  1501G  276.2174300000                                   0
GRID*          1502                          1110.1047930000 -740.1657271000*  1502G
*  1502G  269.6958900000                                   0
GRID*          1601                           735.4614452000 -321.4752190000*  1601G
*  1601G  201.6861040000                                   0
GRID*          1602                           719.0791973500 -321.8893812000*  1602G
*  1602G  167.7378190000                                   0
GRID*          1701                           917.3858480000 -550.9002126000*  1701G
*  1701G  229.4678850000                                   0
GRID*           201                           279.1302763000    0.0          *  201G
*   201G  146.6867195000                                   0
$
$     KRASH MASS POINT/NODE POINTS CONVERTED TO RBAR ELEMENTS
$
RBAR          501     500     501  123456                  123456
PLOTEL        501     500     501
RBAR         1101    1100    1101  123456                  123456
PLOTEL       1101    1100    1101
RBAR         1102    1100    1102  123456                  123456
PLOTEL       1102    1100    1102
RBAR         1103    1100    1103  123456                  123456
PLOTEL       1103    1100    1103
RBAR         1201    1200    1201  123456                  123456
PLOTEL       1201    1200    1201
RBAR         1401    1400    1401  123456                  123456
PLOTEL       1401    1400    1401
RBAR         1501    1500    1501  123456                  123456
PLOTEL       1501    1500    1501
RBAR         1502    1500    1502  123456                  123456
PLOTEL       1502    1500    1502
RBAR         1601    1600    1601  123456                  123456
PLOTEL       1601    1600    1601
RBAR         1602    1600    1602  123456                  123456
PLOTEL       1602    1600    1602
RBAR         1701    1700    1701  123456                  123456
PLOTEL       1701    1700    1701
RBAR          201     200     201  123456                  123456
PLOTEL        201     200     201
$
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 2 OF 11)

```
LT.SAMPLE.DATA                                                    AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     5
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                      I N P U T   B U L K   D A T A   D E C K   E C H O

                  .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                  $    KRASH MASS POINTS CONVERTED TO NASTRAN CONM2 CARDS
                  $
                  CONM2         100     100             2.053                                   WT  100
                  +WT  100    5757.      0.   20000.      0.        0.    7500.
                  CONM2         200     200            11.742                                   WT  200
                  +WT  200   44540.      0. 150000.       0.        0.   49500.
                  CONM2         300     300            19.842                                   WT  300
                  +WT  300   81390.      0.   48468.      0.        0.   51545.
                  CONM2         400     400            16.964                                   WT  400
                  +WT  400   98135.      0.   33358.      0.        0.   39695.
                  CONM2         500     500            28.177                                   WT  500
                  +WT  500  245530.      0.   62835.      0.        0.   73255.
                  CONM2         600     600            10.235                                   WT  600
                  +WT  600   40692.      0.   60000.      0.        0. 100000.
                  CONM2         700     700            11.905                                   WT  700
                  +WT  700   43768.      0.   70000.      0.        0. 100000.
                  CONM2         800     800            12.874                                   WT  800
                  +WT  800   44049.      0.   90000.      0.        0. 150000.
                  CONM2         900     900             7.386                                   WT  900
                  +WT  900   48125.      0.   20894.      0.        0.   13020.
                  CONM2        1000    1000             7.999                                   WT 1000
                  +WT 1000 107650.       0.   53990.      0.        0.   79315.
                  CONM2        1100    1100            25.053                                   WT 1100
                  +WT 1100   15213.      0. 138580.       0.        0. 360000.
                  CONM2        1200    1200            26.077                                   WT 1200
                  +WT 1200   19510.      0. 122630.       0.        0. 300000.
                  CONM2        1300    1300            13.696                                   WT 1300
                  +WT 1300    7272.      0.   52619.      0.        0. 110000.
                  CONM2        1400    1400             9.738                                   WT 1400
                  +WT 1400    4408.      0.   25823.      0.        0.   60000.
                  CONM2        1500    1500             3.996                                   WT 1500
                  +WT 1500    1671.      0.    9014.      0.        0.   18000.
                  CONM2        1600    1600            13.990                                   WT 1600
                  +WT 1600    3652.      0.   25746.      0.        0.   29375.
                  CONM2        1700    1700            13.345                                   WT 1700
                  +WT 1700    3712.      0.   24588.      0.        0.   28178.
                  CONM2        1800    1800             4.979                                   WT 1800
                  +WT 1800     371.      0.    1600.      0.        0.    2000.
                  CONM2        1900    1900             0.308                                   WT 1900
                  +WT 1900      12.      0.     150.      0.        0.     250.
                  CONM2        2000    2000             1.295                                   WT 2000
                  +WT 2000     500.      0.     500.      0.        0.     500.
                  CONM2        2100    2100             1.295                                   WT 2100
                  +WT 2100     500.      0.     500.      0.        0.     500.
                  $
                  $     KRASH SYMMETRIC MODEL BOUNDARY POINTS CONVERTED TO NASTRAN GROUNDED GRIDS
                  $
                  GRID*        1199                      852.0816817000     0.0          *  1199G
                  *  1199G  205.4417780000                          246
                  GRID*        1499                     1110.1047930000     0.0          *  1499G
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 3 OF 11)

INITIAL CONDITION STATIC SOLUTION

```
                              I N P U T   B U L K   D A T A   D E C K   E C H O

.   .  .. 2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
*  1499G  269.6958900000                                   246
GRID*     1498                          1110.1047930000    0.0          *  1498G
*  1498G  269.6958900000                                   246
$
$     KRASH BEAM ELEMENTS CONVERTED TO NASTRAN CBAR, PBAR, AND MAT1 CARDS
$
CBAR*     1000              1000              100               200             *  1000S
*  1000S  0.0              -1.000000000000  0.0                                 *  1000T
*  1000T                                                                        *  1000U
*  1000U
PBAR*               1000              1000    16.00000000  18500.00000000*  1000A
*  1000A  31000.00000000  49500.00000000
MAT1*               1000      10000000.00      3800000.00                     *  1000B
*  1000B                                                  0.100000000000*  1000C
*  1000C         35000.000         34000.000        17000.000
$
CBAR*     2000              2000              200               300             *  2000S
*  2000S  0.0              -1.000000000000  0.0                                 *  2000T
*  2000T                                                                        *  2000U
*  2000U
PBAR*               2000              2000    18.00000000  21500.00000000*  2000A
*  2000A  38500.00000000  60000.00000000
MAT1*               2000      10000000.00      3800000.00                     *  2000B
*  2000B                                                  0.100000000000*  2000C
*  2000C         35000.000         34000.000        17000.000
$
CBAR*     3000              3000              300               400             *  3000S
*  3000S  0.0              -1.000000000000  0.0                                 *  3000T
*  3000T                                                                        *  3000U
*  3000U
PBAR*               3000              3000    18.00000000  21500.00000000*  3000A
*  3000A  43000.00000000  64500.00000000
MAT1*               3000      10000000.00      3800000.00                     *  3000B
*  3000B                                                  0.100000000000*  3000C
*  3000C         35000.000         34000.000        17000.000
$
CBAR*     4000              4000              400               500             *  4000S
*  4000S  0.0              -1.000000000000  0.0                                 *  4000T
*  4000T                                                                        *  4000U
*  4000U
PBAR*               4000              4000    29.50000000  23250.00000000*  4000A
*  4000A  68000.00000000  91250.00000000
MAT1*               4000      10000000.00      3800000.00                     *  4000B
*  4000B                                                  0.100000000000*  4000C
*  4000C         35000.000         34000.000        17000.000
$
CBAR*     5000              5000              500               600             *  5000S
*  5000S  0.0              -1.000000000000  0.0                                 *  5000T
*  5000T                                                                        *  5000U
*  5000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 4 OF 11)

```
LT.SAMPLE.DATA                                                   AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     7
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                     I N P U T   B U L K   D A T A   D E C K   E C H O

             .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
             PBAR*               5000            5000     29.50000000  23250.00000000*  5000A
             *  5000A 58000.00000000  81250.00000000
             MAT1*               5000     10000000.00      3800000.00                *  5000B
             *  5000B                                                  0.100000000000*  5000C
             *  5000C       35000.000       34000.000       17000.000
             $
             CBAR*       6000            6000            600             700         *  6000S
             *  6000S 0.0             -1.000000000000  0.0                             *  6000T
             *  6000T                                                                  *  6000U
             *  6000U
             PBAR*               6000            6000     28.50000000  28500.00000000*  6000A
             *  6000A 68000.00000000  96500.00000000
             MAT1*               6000     10000000.00      3800000.00                *  6000B
             *  6000B                                                  0.100000000000*  6000C
             *  6000C       35000.000       34000.000       17000.000
             $
             CBAR*       7000            7000            700             800         *  7000S
             *  7000S 0.0             -1.000000000000  0.0                             *  7000T
             *  7000T                                                                  *  7000U
             *  7000U
             PBAR*               7000            7000     24.00000000  31000.00000000*  7000A
             *  7000A 57000.00000000  88000.00000000
             MAT1*               7000     10000000.00      3800000.00                *  7000B
             *  7000B                                                  0.100000000000*  7000C
             *  7000C       35000.000       34000.000       17000.000
             $
             CBAR*       8000            8000            800             900         *  8000S
             *  8000S 0.0             -1.000000000000  0.0                             *  8000T
             *  6000T                                                                  *  8000U
             *  8000U
             PBAR*               8000            8000     18.50000000  16750.00000000*  8000A
             *  8000A 28000.00000000  44750.00000000
             MAT1*               8000     10000000.00      3800000.00                *  8000B
             *  8000B                                                  0.100000000000*  8000C
             *  8000C       35000.000       34000.000       17000.000
             $
             CBAR*       9000            9000            900             1000        *  9000S
             *  9000S 0.0             -1.000000000000  0.0                             *  9000T
             *  9000T                                                                  *  9000U
             *  9000U
             PBAR*               9000            9000     12.50000000   4750.00000000*  9000A
             *  9000A 45000.00000000  49750.00000000
             MAT1*               9000     10000000.00      3800000.00                *  9000B
             *  9000B                                                  0.100000000000*  9000C
             *  9000C       35000.000       34000.000       17000.000
             $
             CBAR*      10000           10000            500             1101        * 10000S
             * 10000S -0.931764722649  0.363062669031  0.0                             * 10000T
             * 10000T                                                                  * 10000U
             * 10000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 5 OF 11)

INITIAL CONDITION STATIC SOLUTION

```
                              I N P U T   B U L K   D A T A   D E C K   E C H O

 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
PBAR*              10000             10000      54.00000000 114000.00000000* 10000A
* 10000A  15900.00000000  48000.00000000
MAT1*              10000       10000000.00       3800000.0                  * 10000B
* 10000B                                                 0.100000000000* 10000C
* 10000C       35000.000         34000.000       17000.000
$
CBAR*         11000           11000           1101            1200          * 11000S
* 11000S -0.890910986066 -0.454177955109  0.0                              * 11000T
* 11000T                                                                    * 11000U
* 11000U
PBAR*              11000             11000      63.20000000 102000.00000000* 11000A
* 11000A  11400.00000000  26000.00000000
MAT1*              11000       10000000.00      3800000.00                  * 11000B
* 11000B                                                 0.100000000000* 11000C
* 11000C       35000.000         34000.000       17000.000
$
CBAR*         12000           12000           1200            1300          * 12000S
* 12000S -0.867845992474 -0.496833305392  0.0                              * 12000T
* 12000T                                                                    * 12000U
* 12000U
PBAR*              12000             12000      56.30000000  58000.00000000* 12000A
* 12000A   4700.00000000  10000.00000000
MAT1*              12000       10000000.00      3800000.00                  * 12000B
* 12000B                                                 0.100000000000* 12000C
* 12000C       35000.000         34000.000       17000.000
$
CBAR*         13000           13000           1300            1400          * 13000S
* 13000S -0.832330947833 -0.554278985060  0.0                              * 13000T
* 13000T                                                                    * 13000U
* 13000U
PBAR*              13000             13000      40.70000000  21000.00000000* 13000A
* 13000A   2000.00000000   4800.00000000
MAT1*              13000       10000000.00      3800000.00                  * 13000B
* 13000B                                                 0.100000000000* 13000C
* 13000C       35000.000         34000.000       17000.000
$
CBAR*         14000           14000           1400            1501          * 14000S
* 14000S -0.841546482505 -0.540184707099  0.0                              * 14000T
* 14000T                                                                    * 14000U
* 14000U
PBAR*              14000             14000      20.00000000   8000.00000000* 14000A
* 14000A   1200.00000000   2700.00000000
MAT1*              14000       10000000.00      3800000.00                  * 14000B
* 14000B                                                 0.100000000000* 14000C
* 14000C       35000.000         34000.000       17000.000
$
CBAR*         15000           15000           1201            1601          * 15000S
* 15000S  0.001134791926  0.999999356123  0.0                              * 15000T
* 15000T                                                                    * 15000U
* 15000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 6 OF 11)

INITIAL CONDITION STATIC SOLUTION

I N P U T   B U L K   D A T A   D E C K   E C H O

```
 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
PBAR*                15000              15000       8.00000000     100.00000000* 15000A
* 15000A   732.00000000    220.80000000
MAT1*                15000      10500000.00       4000000.00                   * 15000B
* 15000B                                                     0.100000000000* 15000C
* 15000C       47000.000        39000.000        22000.000
$
CBAR*      16000            16000             1401             1701          * 16000S
* 16000S 0.005384743970  0.999985502161  0.0                                 * 16000T
* 16000T                                                                     * 16000U
* 16000U
PBAR*                16000              16000       8.00000000     100.00000000* 16000A
* 16000A   732.00000000    220.80000000
MAT1*                16000      10500000.00       4000000.00                   * 16000B
* 16000B                                                     0.100000000000* 16000C
* 16000C       47000.000        39000.000        22000.000
$
CBAR*      17000            17000             1102             1800          * 17000S
* 17000S 0.0            -0.999977553648  0.006700164201                      * 17000T
* 17000T                                                                     * 17000U
* 17000U
PBAR*                17000              17000       0.29919509     239.00000000* 17000A
* 17000A   239.00000000    150.00000000
MAT1*                17000      30000000.00      11000000.00                   * 17000B
* 17000B                                                     0.100000000000* 17000C
* 17000C       75000.000        75000.000        37500.000
$
CBAR*      18000            18000             1103             1800          * 18000S
* 18000S 0.0            -0.999977553648  0.006700164201                      * 18000T
* 18000T                                                                     * 18000U
* 18000U
PBAR*                18000              18000       0.01000000     239.00000000* 18000A
* 18000A   239.00000000    150.00000000
MAT1*                18000      30000000.00      11000000.00                   * 18000B
* 18000B                                                     0.100000000000* 18000C
* 18000C       75000.000        75000.000        37500.000
$
CBAR*      19000            19000              201             1900          * 19000S
* 19000S 0.0            -1.000000000000  0.0                                 * 19000T
* 19000T                                                                     * 19000U
* 19000U
PBAR*                19000              19000       0.05243324      16.25000000* 19000A
* 19000A    16.25000000      2.50000000
MAT1*                19000      30000000.00      11000000.00                   * 19000B
* 19000B                                                     0.100000000000* 19000C
* 19000C       75000.000        75000.000        37500.000
$
CBAR*      20000            20000              600             1200          * 20000S
* 20000S -0.929399243434 0.369075935688  0.0                                 * 20000T
* 20000T                       56                                            * 20000U
* 20000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 7 OF 11)

INITIAL CONDITION STATIC SOLUTION

```
                    I N P U T   B U L K   D A T A   D E C K   E C H O

 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
PBAR*                   20000           20000      40.70000000  21000.00000000* 20000A
* 20000A      2000.00000000  4800.00000000
MAT1*                   20000     10000000.00       3800000.00                 * 20000B
* 20000B                                                        0.100000000000* 20000C
* 20000C          35000.000       34000.000        17000.000
$
CBAR*        21000           21000            900             1400             * 21000S
* 21000S -0.879345610002 0.476184101131  0.0                                    * 21000T
* 21000T          6               6                                            * 21000U
* 21000U
PBAR*                   21000           21000      40.70000000  21000.00000000* 21000A
* 21000A      2000.00000000  4800.00000000
MAT1*                   21000     10000000.00       3800000.00                 * 21000B
* 21000B                                                        0.100000000000* 21000C
* 21000C          35000.000       34000.000        17000.000
$
CBAR*        22000           22000            1200            1199             * 22000S
* 22000S 1.000000000000  0.000000000000  0.0                                    * 22000T
* 22000T                                                                       * 22000U
* 22000U
PBAR*                   22000           22000      40.70000000  21000.00000000* 22000A
* 22000A      2000.00000000  4800.00000000
MAT1*                   22000     10000000.00       3800000.00                 * 22000B
* 22000B                                                        0.100000000000* 22000C
* 22000C          35000.000       34000.000        17000.000
$
CBAR*        23000           23000            200             2000             * 23000S
* 23000S 0.0             1.000000000000  0.0                                    * 23000T
* 23000T                                                                       * 23000U
* 23000U
PBAR*                   23000           23000       0.10178943      0.50000000* 23000A
* 23000A         0.50000000      0.50000000
MAT1*                   23000      1000000.00        400000.00                 * 23000B
* 23000B                                                        0.632230474716* 23000C
* 23000C          16000.000       16000.000        17000.000
$
$
$      DRI MASSES CONNECTED WITH RBAR ELEMENTS
$
RBAR         24000      200     2100  123456                     123456
CBAR*        25000           25000            1500            1600             * 25000S
* 25000S 0.730502420322  0.682910106752  0.0                                    * 25000T
* 25000T                                                                       * 25000U
* 25000U
PBAR*                   25000           25000       0.0             0.0        * 25000A
* 25000A         0.0             0.0
MAT1*                   25000     10000000.00       3800000.00                 * 25000B
* 25000B                                                        0.100000000000* 25000C
* 25000C          35000.000       34000.000        17000.000
$
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 8 OF 11)

INITIAL CONDITION STATIC SOLUTION

I N P U T   B U L K   D A T A   D E C K   E C H O

```
.  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
CBAR*      26000          26000          1502           1602          * 26000S
* 26000S 0.730502420322 0.682910106752 0.0                            * 26000T
* 26000T                                                              * 26000U
* 26000U
PBAR*              26000          26000      0.0            0.0       * 26000A
* 26000A    0.0            0.0
MAT1*              26000     10000000.00     3800000.00               * 26000B
* 26000B                                                 0.100000000000* 26000C
* 26000C       35000.000      34000.000      17000.000
$
CBAR*      27000          27000          1500           1499          * 27000S
* 27000S 1.000000000000 0.000000000000 0.0                            * 27000T
* 27000T                                                              * 27000U
* 27000U
PBAR*              27000          27000      0.0        8000.00000000* 27000A
* 27000A  1200.00000000  2700.00000000
MAT1*              27000     10000000.00     3800000.00               * 27000B
* 27000B                                                 0.100000000000* 27000C
* 27000C       35000.000      34000.000      17000.000
$
CBAR*      28000          28000          1502           1498          * 28000S
* 28000S 1.000000000000 0.000000000000 0.0                            * 28000T
* 28000T                                                              * 28000U
* 28000U
PBAR*              28000          28000    20.00000000  8000.00000000* 28000A
* 28000A  1200.00000000  2700.00000000
MAT1*              28000     10000000.00     3800000.00               * 28000B
* 28000B                                                 0.100000000000* 28000C
* 28000C       35000.000      34000.000      17000.000
$
$
$   MISCELLANEOUS CARDS
$
EIGR    999     MGIV                          40                      EIGR
+EIGR   MAX
$
$   FORCE AND MOMENT CARDS, BASED ON FNET CALCS
$
FORCE*          1              100                             1.0      *  1000M
*  1000M   -7.56785966      0.0          -722.35195283
MOMENT*         2              100                             1.0      *  1000N
*  1000N     0.0           74.8788473      0.0
FORCE*          1              200                             1.0      *  2000M
*  2000M  -31.55523283      0.0         -4095.04371998
MOMENT*         2              200                             1.0      *  2000N
*  2000N     0.0          561.5913546      0.0
FORCE*          1              300                             1.0      *  3000M
*  3000M  -22.99168396      0.0         -6531.19035496
MOMENT*         2              300                             1.0      *  3000N
*  3000N     0.0          181.4595265      0.0
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 9 OF 11)

```
LT.SAMPLE.DATA                                                                  AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    12
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                  I N P U T   B U L K   D A T A   D E C K   E C H O

                 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                 FORCE*          1               400                             1.0            *  4000M
                 *  4000M      5.84772882      0.0             -4032.34379398
                 MOMENT*         2               400                             1.0            *  4000N
                 *  4000N      0.0             124.8885574     0.0
                 FORCE*          1               500                             1.0            *  5000M
                 *  5000M      70.60230249     0.0             -6685.78934577
                 MOMENT*         2               500                             1.0            *  5000N
                 *  5000N      0.0             235.2506184     0.0
                 FORCE*          1               600                             1.0            *  6000M
                 *  6000M      42.33434369     0.0             -2872.19975973
                 MOMENT*         2               600                             1.0            *  6000N
                 *  6000N      0.0             224.6365418     0.0
                 FORCE*          1               700                             1.0            *  7000M
                 *  7000M      59.41232873     0.0             -3344.87377537
                 MOMENT*         2               700                             1.0            *  7000N
                 *  7000N      0.0             262.0759655     0.0
                 FORCE*          1               800                             1.0            *  8000M
                 *  8000M      83.87946652     0.0             -4482.06723327
                 MOMENT*         2               800                             1.0            *  8000N
                 *  8000N      0.0             336.9548127     0.0
                 FORCE*          1               900                             1.0            *  9000M
                 *  9000M      61.30714759     0.0             -2573.72885512
                 MOMENT*         2               900                             1.0            *  9000N
                 *  9000N      0.0             78.2259318      0.0
                 FORCE*          1               1000                            1.0            * 10000M
                 * 10000M      27.38244991     0.0             -11756.62817664
                 MOMENT*         2               1000                            1.0            * 10000N
                 * 10000N      0.0             202.1354482     0.0
                 FORCE*          1               1100                            1.0            * 11000M
                 * 11000M      23.12541991     103.21494745    5960.50952114
                 MOMENT*         2               1100                            1.0            * 11000N
                 * 11000N      -14.5761285     518.8725333     6.2085507
                 FORCE*          1               1200                            1.0            * 12000M
                 * 12000M      -113.48138880   368.30966802    18339.92339842
                 MOMENT*         2               1200                            1.0            * 12000N
                 * 12000N      -22.8769999     459.2326870     9.4854969
                 FORCE*          1               1300                            1.0            * 13000M
                 * 13000M      -167.47482007   479.82881212    16214.98538780
                 MOMENT*         2               1300                            1.0            * 13000N
                 * 13000N      -12.6374941     197.1100875     5.4498769
                 FORCE*          1               1400                            1.0            * 14000M
                 * 14000M      -81.06087995    457.28347940    14133.50024522
                 MOMENT*         2               1400                            1.0            * 14000N
                 * 14000N      -8.3753450      96.7618458      4.3561419
                 FORCE*          1               1500                            1.0            * 15000M
                 * 15000M      -33.41324906    106.98780051    4729.90095725
                 MOMENT*         2               1500                            1.0            * 15000N
                 * 15000N      -1.4133070      33.7559939      0.9256609
                 FORCE*          1               1600                            1.0            * 16000M
                 * 16000M      24.83744530     -20.57526084    -5010.13312244
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 10 OF 11)

```
LT.SAMPLE.DATA                                                                      AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    13
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                  I N P U T   B U L K   D A T A   D E C K   E C H O

                                  .  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
                                  MOMENT*        2               1600                              1.0        * 16000N
                                  * 16000N   -241.0580577    96.2258635   -9971.3569011
                                  FORCE*         1               1700                              1.0        * 17000M
                                  * 17000M    49.36181777   -16.45123705  -4784.14479814
                                  MOMENT*        2               1700                              1.0        * 17000N
                                  * 17000N   -229.2633806    91.8381949   -9968.4049129
                                  FORCE*         1               1800                              1.0        * 18000M
                                  * 18000M    13.79198437    0.0          -1886.26038382
                                  MOMENT*        2               1800                              1.0        * 18000N
                                  * 18000N     -0.0242191     5.9903734        0.0168548
                                  FORCE*         1               1900                              1.0        * 19000M
                                  * 19000M    -1.02852487    0.0           -116.10773109
                                  MOMENT*        2               1900                              1.0        * 19000N
                                  * 19000N     0.0            0.5615914       0.0
                                  FORCE*         1               2000                              1.0        * 20000M
                                  * 20000M    -3.30879590    0.0           -485.95650668
                                  MOMENT*        2               2000                              1.0        * 20000N
                                  * 20000N     0.0            1.8719712       0.0
                                  FORCE1*         3               1102       10116.00000000      1800       *   1000P
                                  *  1000P       1102
                                  FORCE1*         3               1800       10116.00000000      1102       *   1000Q
                                  *  1000Q       1800
                                  FORCE1*         3                201        1565.50000000      1900       *   2000P
                                  *  2000P        201
                                  FORCE1*         3               1900        1565.50000000       201       *   2000Q
                                  *  2000Q       1900
                                  FORCE1*         3               1502         40531.463295      1502       * 28000D
                                  * 28000D       1498
                                  FORCE1*         3               1498         40531.463295      1498       * 28000E
                                  * 28000E       1502
                                  $
                                  LOAD       10      1.0      1.0     1       1.0      2       1.0     3
                                  $
                                  $
                                  $
                                  ENDDATA

                                  INPUT BULK DATA CARD COUNT =      536
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 11 OF 11)

input data set, using the following NASTRAN elements.

- GRID points
- CBAR bar elements (with PBAR properties and MAT1 materials)
- RBAR rigid bar elements
- FORCE and MOMENT cards for applied loads

Although only a linear model is formed, the following KRASH85 nonlinearities are included in the NASTRAN model:

- Oleo beam elements (initial position must be fully extended)
- Unsymmetrical beam elements

A nonlinear KRASH model is acceptable (KR tables), as long as the initial conditions are in the linear region. The executive and case control decks, plus the bulk data deck, are all contained in date set XYZ.NASBLK.DATA, which is generated automatically by program KRASHIC.

2.3.2.4 Sorted Bulk Data Deck Echo

This is just an alphabetically sorted version of the bulk data deck shown in figure 2-12. The last page of this is shown in figure 2-13. The EPSILON value shown is a measure of the error in the static solution. Any value less than E-7 is acceptable. Generally speaking, any significant error in the model will result in a very large value for EPSILON (>0.1) or will cause the NASTRAN solution to terminate with an error message.

2.3.2.5 Displacement Vector

Figure 2-14 shows a sample of the displacement vector output. These data represent the desired solution. The three translations and rotations at each grid point in the NASTRAN model are shown. The sign convention for these displacements/rotations within the NASTRAN model is as follows:

T1 Positive deflection aft, inches
T2 Positive deflection right, inches

T3 Positive deflection up, inches

R1 Positive rotation left wing down, radians

R2 Positive rotation nose up, radians

R3 Positive rotation nose left, radians

All deflections/rotations are measured in an axis system that is parallel to the c.g. coordinate system defined in Section 2.2.

The grid point identifications within NASTRAN are related to the KRASH85 mass and mode points as follows:

Node point (I, M) becomes grid point (100*I + M) e.g. Node point 11, 2 becomes grid point 1102. Mass point 5 becomes grid point 500.

In figure 2-14, grid points 1199, 1498 and 1499 do not correspond to any node points in the KRASH model. In the KRASH model there are two transverse beams attached to mass 15 and one to mass 12; i.e., beams which connect laterally between mass 15 (and 12) and a phantom (unnumbered) point at the same location on the opposite side of the airplane. For these lateral beams, a grid point on the airplane plane of symmetry (y = 0) is established in the NASTRAN model in order to constrain the deflections of lateral beams. Grid points 1199, 1498, and 1499 are all such constrained grid points.

The deflections and rotations for grid point 500 (mass point 5) are all zero. This is because mass point 5 was specified by the user to be the constraint point in the model. This was done by inputting NBAL = 5 on card 60 of the input format (figure 2-3). This can be seen on card sequence number 90 in the input data echo for this sample case (figure 2-8).

2.3.2.6 Load Vector

Figure 2-15 shows the vector of applied loads for the sample case. These are the NASTRAN input net loads generated by KRASHIC in subroutine NETFOR. The sign convention for these loads is the same as for the displacements, as defined in the previous section. The loads shown for grid points 201, 1102, 1498 and 1502 are the result of using FORCE1 type cards in the

```
LT.SAMPLE.DATA                                                                    AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    23
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                               S O R T E D   B U L K   D A T A   E C H O
            CARD
            COUNT        .  1  ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
             451-        PBAR    *28000            28000               20.00000000         8000.00000000   * 28000A
             452-        * 28000A1200.00000000     2700.00000000
             453-        PLOTEL  201     200     201
             454-        PLOTEL  501     500     501
             455-        PLOTEL  1101    1100    1101
             456-        PLOTEL  1102    1100    1102
             457-        PLOTEL  1103    1100    1103
             458-        PLOTEL  1201    1200    1201
             459-        PLOTEL  1401    1400    1401
             460-        PLOTEL  1501    1500    1501
             461-        PLOTEL  1502    1500    1502
             462-        PLOTEL  1601    1600    1601
             463-        PLOTEL  1602    1600    1602
             464-        PLOTEL  1701    1700    1701
             465-        RBAR    201     200     201     123456                          123456
             466-        RBAR    501     500     501     123456                          123456
             467-        RBAR    1101    1100    1101    123456                          123456
             468-        RBAR    1102    1100    1102    123456                          123456
             469-        RBAR    1103    1100    1103    123456                          123456
             470-        RBAR    1201    1200    1201    123456                          123456
             471-        RBAR    1401    1400    1401    123456                          123456
             472-        RBAR    1501    1500    1501    123456                          123456
             473-        RBAR    1502    1500    1502    123456                          123456
             474-        RBAR    1601    1600    1601    123456                          123456
             475-        RBAR    1602    1600    1602    123456                          123456
             476-        RBAR    1701    1700    1701    123456                          123456
             477-        RBAR    24000   200     2100    123456                          123456
                         ENDDATA

                 TOTAL COUNT=   478



*** USER INFORMATION MESSAGE 3035 FOR DATA BLOCK KLL

   LOAD SEQ. NO.             EPSILON              STRAIN   ENERGY     EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS
             1            -1.1010772E-13          1.9329606E+05
```

FIGURE 2-13. MSC/NASTRAN SORTED BULK DATA DECK

21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

D I S P L A C E M E N T   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
100	G	-3.089143E-02	0.0	-9.927106E-01	0.0	-2.240265E-03	0.0
200	G	-2.848941E-02	0.0	-7.668377E-01	0.0	-2.228401E-03	0.0
201	G	1.302763E-01	0.0	-8.132805E-01	0.0	-2.228401E-03	0.0
300	G	-7.956203E-03	0.0	-4.223564E-01	0.0	-2.016658E-03	0.0
400	G	-3.881565E-03	0.0	-1.467094E-01	0.0	-1.310210E-03	0.0
500	G	0.0	0.0	0.0	0.0	0.0	0.0
501	G	0.0	0.0	0.0	0.0	0.0	0.0
600	G	3.899802E-04	0.0	-1.395649E-01	0.0	1.905725E-03	0.0
700	G	-1.741050E-02	0.0	-3.224221E-01	0.0	2.646156E-03	0.0
800	G	1.960022E-02	0.0	-8.574673E-01	0.0	3.925506E-03	0.0
900	G	1.623366E-01	0.0	-1.646018E+00	0.0	5.791202E-03	0.0
1000	G	4.121324E-01	0.0	-2.947553E+00	0.0	6.380439E-03	0.0
1100	G	-2.376698E-02	-6.204827E-02	4.549806E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1101	G	-1.923044E-02	-6.048078E-02	3.946607E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1102	G	-1.296102E-02	-1.657880E-01	7.333746E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1103	G	-1.296102E-02	-1.657880E-01	7.333746E-01	-6.692734E-03	-2.201433E-03	-5.605535E-04
1199	G	-9.159946E-02	0.0	5.671601E-01	0.0	-6.671559E-03	0.0
1200	G	-2.183176E-01	4.138304E-02	2.341775E+00	-1.306023E-02	-6.671559E-03	-9.325789E-04
1201	G	-2.439480E-01	3.842933E-02	2.721844E+00	-1.306023E-02	-6.671559E-03	-9.325789E-04
1300	G	-6.008078E-01	3.054584E-01	6.170222E+00	-2.241259E-02	-1.032131E-02	-1.681531E-03
1400	G	-1.368588E+00	6.399867E-01	1.084582E+01	-2.562689E-02	-7.394198E-03	-5.296092E-03
1401	G	-1.022665E+00	2.900504E-01	9.660528E+00	-2.562689E-02	-7.394198E-03	-5.296092E-03
1498	G	-6.724794E-01	0.0	8.267691E+00	0.0	-9.067751E-03	0.0
1499	G	-6.724794E-01	0.0	8.267691E+00	0.0	-9.067751E-03	0.0
1500	G	-2.495204E+00	4.342735E-01	1.459584E+01	-1.709927E-02	-9.067751E-03	-4.925180E-03
1501	G	-2.554648E+00	3.717274E-01	1.491737E+01	-1.709927E-02	-9.067751E-03	-4.925180E-03
1502	G	-2.495204E+00	4.342735E-01	1.459584E+01	-1.709927E-02	-9.067751E-03	-4.925180E-03
1600	G	7.919782E-02	-2.893808E-01	1.937816E+00	-1.295898E-02	-9.379067E-03	-1.573276E-03
1601	G	-2.385539E-01	1.247806E-01	2.086101E+00	-1.295898E-02	-9.379067E-03	-1.573276E-03
1602	G	7.919782E-02	-2.893808E-01	1.937816E+00	-1.295898E-02	-9.379067E-03	-1.573276E-03
1700	G	-6.952541E-01	-3.463942E-02	8.834657E+00	-2.537073E-02	-9.936508E-03	-5.952671E-03
1701	G	-1.014149E+00	6.997894E-01	8.967865E+00	-2.537073E-02	-9.936508E-03	-5.952671E-03
1800	G	1.832867E-01	-7.628582E-01	6.224991E-01	-6.689236E-03	-2.204064E-03	-5.605265E-04
1900	G	2.696309E-01	0.0	-8.798568E-01	0.0	-2.223161E-03	0.0
2000	G	-9.809846E-02	0.0	-8.621072E-01	0.0	-4.137866E-03	0.0
2100	G	-7.305723E-02	0.0	-7.669372E-01	0.0	-2.228401E-03	0.0

FIGURE 2-14. MSC/NASTRAN DISPLACEMENT VECTOR

21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

L O A D   V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
100	G	-7.567860E+00	0.0	-7.223518E+02	0.0	7.487885E+01	0.0
200	G	-3.155522E+01	0.0	-4.095044E+03	0.0	5.615913E+02	0.0
201	G	-3.488073E+00	0.0	1.5[illegible]496E+03	0.0	0.0	0.0
300	G	-2.299168E+01	0.0	-6.531187E+03	0.0	1.814595E+02	0.0
400	G	5.847729E+00	0.0	-4.032344E+03	0.0	1.248885E+02	0.0
500	G	7.060229E+01	0.0	-6.685789E+03	0.0	2.352506E+02	0.0
600	G	4.233434E+01	0.0	-2.872200E+03	0.0	2.246365E+02	0.0
700	G	5.941232E+01	0.0	-3.344874E+03	0.0	2.620759E+02	0.0
800	G	8.387946E+01	0.0	-4.482066E+03	0.0	3.369546E+02	0.0
900	G	6.130714E+01	0.0	-2.573729E+03	0.0	7.822592E+01	0.0
1000	G	2.738245E+01	0.0	-1.175662E+04	0.0	2.021354E+02	0.0
1100	G	2.312541E+01	1.032149E+02	5.960508E+03	-1.457613E+01	5.188723E+02	6.208550E+00
1102	G	-2.228247E+01	6.777931E+01	1.011575E+04	0.0	0.0	0.0
1200	G	-1.134814E+02	3.683096E+02	1.833992E+04	-2.287700E+01	4.592327E+02	9.485497E+00
1300	G	-1.674748E+02	4.798286E+02	1.621498E+04	-1.263749E+01	1.971101E+02	5.449877E+00
1400	G	-8.106087E+01	4.572834E+02	1.413350E+04	-8.375344E+00	9.676184E+01	4.356141E+00
1498	G	0.0	-4.053146E+04	0.0	0.0	0.0	0.0
1500	G	-3.341324E+01	1.069878E+02	4.729898E+03	-1.413306E+00	3.375598E+01	9.256608E-01
1502	G	0.0	4.053146E+04	0.0	0.0	0.0	0.0
1600	G	2.483743E+01	-2.057526E+01	-5.010133E+03	-2.410580E+02	9.622586E+01	-9.971355E+03
1700	G	4.936182E+01	-1.645123E+01	-4.784145E+03	-2.292634E+02	9.183818E+01	-9.968402E+03
1800	G	3.607445E+01	-6.777931E+01	-1.200200E+04	-2.421910E-02	5.990373E+00	1.685480E-02
1900	G	2.459549E+00	0.0	-1.681604E+03	0.0	5.615914E-01	0.0
2000	G	-3.308795E+00	0.0	-4.859563E+02	0.0	1.871971E+00	0.0

FIGURE 2-15. MSC/NASTRAN LOAD VECTOR

NASTRAN input. These cards apply a constant axial force between two defined grid points. The FORCE1 cards in the sample case are used to account for nonlinear effects in oleos and unsymmetrical beams. There are no externally applied loads at node points, only at mass points.

2.3.2.7 Forces of Single-Point Constraint

Figure 2-16 shows the NASTRAN output that summarizes the forces of single-point constraint. This shows the forces and moments that are applied at the model constrai t points to balance the model. For point 500, constraints are specified in all six directions, so corresponding forces are output. Note that the loads for the symmetric degrees of freedom (T1, T3, R2) are all very small, indicating that a well balanced set of applied loads is being used as input. This is the result of including inertia relief loads in the calculated net loads used as input to NASTRAN. The constraint forces in the anti-symmetric directions (T2, R1, R3) result from the geometry of the model. A half-airplane model is used, and wing loads come into mass 5. The constraint loads shown correspond to the missing loads that the right wing would have supplied. The same is true for grid points 600 and 900. Grid points 1199, 1498 a 1 1499 are center-plane grids as explained in Section 2.3.2.5. The single-point constraint forces shown for these grid points are the reactions at the center of transverse beams in the KRASH model.

2.3.2.8 Forces in Bar Elements

Figure 2-17 illustrates the NASTRAN output that summarizes the bar element static loads. The sign conventions for these loads are shown in figure 2-18, along with the corresponding KRASH85 beam element sign conventions. The KRASH85 loads that correspond to the NASTRAN bar element loads shown in figure 2-17 are as follows:

NASTRAN LOAD	CORRESPONDING KRASH85 LOAD
M1A	-MZI
M2A	MYI
M1B	MZJ
M2B	-MYJ
S1	FYJ
S2	FZJ
FX	FXJ
T	MXJ

NASTRAN plane 1 corresponds to the KRASH85 x-y plane, plane 2 corresponds to the x-z plane. Comparison of the loads in figure 2-17 with the KRASH "STRAIN FORCES" output at time zero will show a very close agreement. Beams which lie entirely in the airplane plane of symmetry (y = 0 plane) are treated differently in NASTRAN and KRASH85. In NASTRAN, the loads are for a half-beam, while in KRASH85 they are for an entire beam. This applies to beams 1000-9000, 19000 and 23000 in figure 2-17. (The NASTRAN bar element numbers are 1000 times the corresponding KRASH85 beam element numbers.) Beam 24000 is missing in the NASTRAN model; this is a DRI element which is modeled as a RBAR rigid element in NASTRAN.

2.3.2.9 Element Strain Energies

Figure 2-19 shows the NASTRAN output of bar element strain energies, in inch-pound units. Missing elements (1000, 25000, 26000) are those that have less than 0.001 percent of the total strain energy. These strain energies agree with the KRASH85 output at time zero, except for oleo and unsymmetrical beam elements. The use of FORCE1 cards in NASTRAN to model these nonlinear elements causes the strain energies calculated by NASTRAN to be incorrect. The KRASH85 strain energies for these elements are correct.

LT.SAMPLE.DATA   AUGUST   3, 1984 MSC/NASTRAN 8/ 1/83   PAGE   26
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
500	G	9.535735E-06	1.102906E+05	-1.647945E-03	1.158149E+07	4.253135E-01	-2.487183E+06
600	G	0.0	-2.197132E+04	0.0	1.765277E+06	0.0	1.538706E+06
900	G	0.0	4.899299E+04	0.0	2.010931E+06	0.0	3.964869E+03
1199	G	0.0	-6.197743E+04	0.0	9.611644E+05	0.0	7.206456E+05
1498	G	0.0	-7.681350E+04	0.0	2.772235E+05	0.0	5.323329E+05
1499	G	0.0	0.0	0.0	2.772235E+05	0.0	5.323329E+05

FIGURE 2-16. MSC/NASTRAN SINGLE-POINT CONSTRAINT FORCES

21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

F O R C E S   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT	BEND-MOMENT END-A		BEND-MOMENT END-B		- SHEAR -		AXIAL	
ID.	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	FORCE	TORQUE
1000	0.0	-7.487885E+01	0.0	7.289244E+04	0.0	-7.223914E+02	-1.141120E-01	0.0
2000	0.0	7.469412E+04	0.0	9.423384E+05	0.0	-5.412238E+03	-2.830302E+02	0.0
3000	0.0	9.421569E+05	0.0	2.854471E+06	0.0	-1.195028E+04	-1.146083E+02	0.0
4000	0.0	2.854346E+06	0.0	6.051349E+06	0.0	-1.597832E+04	-3.910129E+02	0.0
5000	0.0	8.780416E+06	0.0	6.951579E+06	0.0	1.301489E+04	-2.433165E+04	0.0
6000	0.0	7.071534E+06	0.0	5.497074E+06	0.0	1.965147E+04	-2.519321E+04	0.0
7000	0.0	5.496812E+06	0.0	3.567440E+06	0.0	1.199094E+04	-2.774932E+04	0.0
8000	0.0	3.567104E+06	0.0	2.817684E+06	0.0	4.579750E+03	-2.801210E+04	0.0
9000	0.0	2.474329E+06	0.0	2.020132E+02	0.0	1.154472E+04	-2.222242E+03	0.0
10000	-3.186641E+06	-9.800311E+06	4.679865E+06	-3.733758E+06	-6.158012E+04	-4.748982E+04	8.955562E+04	6.447120E+06
11000	5.434646E+06	-6.946986E+06	3.117507E+05	-3.193432E+06	2.957813E+04	-2.167194E+04	1.118354E+05	5.954459E+05
12000	9.487483E+05	-4.564562E+06	2.698350E+06	-5.095244E+05	-9.511133E+03	-2.204306E+04	3.903610E+04	-3.009756E+05
13000	2.677814E+06	-5.073569E+05	3.958839E+06	2.801262E+05	-6.911449E+03	-4.248664E+03	3.846765E+04	-4.6[illegible]E+05
14000	4.043633E+06	6.632647E+05	-3.762905E+06	1.362978E+05	4.146377E+04	2.798940E+03	6.464662E+04	3.27[illegible]1E+05
15000	8.070355E+03	4.640827E+05	9.633930E+03	8.282319E+04	-2.054707E+01	5.010164E+03	1.699646E+01	-1.1[illegible]E+03
16000	8.477410E+03	4.386772E+05	9.709035E+03	7.460462E+04	-1.618520E+01	4.784395E+03	-5.900237E+00	-3.062334E+03
17000	-5.631099E+02	-4.264045E+02	1.222204E-02	2.995131E+00	-6.319184E+00	-4.818592E+00	1.161406E+04	-2.052223E-02
18000	-5.631099E+02	-4.264045E+02	1.222204E-02	2.995131E+00	-6.319184E+00	-4.818592E+00	3.881768E+02	-2.852223E-02
19000	0.0	8.109880E+01	0.0	5.615880E-01	0.0	1.287221E+00	1.681605E+03	0.0
20000	1.520495E+06	-1.596292E+06	-5.776721E-01	6.527750E-01	5.198594E+03	-5.457746E+03	-2.170905E+04	7.[illegible]03806E+05
21000	3.323657E-11	-1.931766E+06	-1.521906E-09	9.507724E+05	2.346161E-12	-4.348730E+03	5.568998E+04	6.557260E+05
22000	-7.206456E+05	-9.611644E+05	-7.206456E+05	-9.611643E+05	0.0	-9.094947E-13	-6.197740E+04	0.0
23000	0.0	9.780161E+01	0.0	-1.871973E+00	0.0	5.007499E+00	-4.859414E+02	0.0
25000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27000	-5.323329E+05	-2.772235E+05	-5.323329E+05	-2.772234E+05	-1.080025E-12	-1.136868E-12	0.0	0.0
28000	-5.323329E+05	-2.772235E+05	-5.323329E+05	-2.772234E+05	-1.080025E-12	-1.136868E-12	-1.173449E+05	0.0

FIGURE 2-17. MSC/NASTRAN BAR ELEMENT FORCES

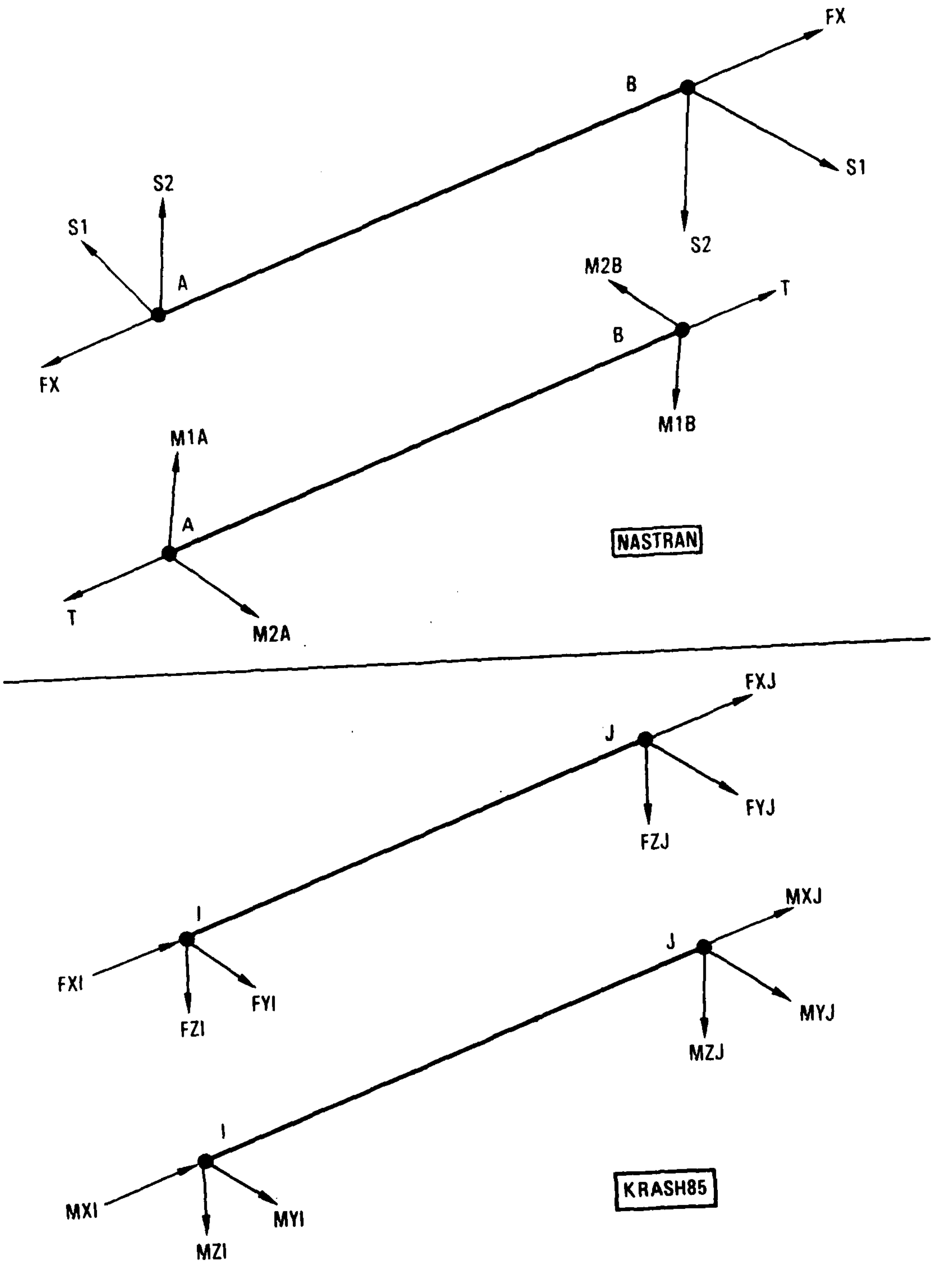


FIGURE 2-18. BAR ELEMENT FORCE SIGN CONVENTIONS, NASTRAN AND KRASH85

T.SAMPLE.DATA AUGUST 3, 1984 MSC/NASTRAN 8/ 1/83 PAGE 30
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

INITIAL CONDITION STATIC SOLUTION

E L E M E N T   S T R A I N   E N E R G I E S

ELEMENT-TYPE = BAR * TOTAL ENERGY OF ALL ELEMENTS IN PROBLEM = 1.932961E+05
SUBCASE 1 TOTAL ENERGY OF ALL ELEMENTS IN SET -1 = 1.932961E+05

ELEMENT-ID	STRAIN-ENERGY	PERCENT OF TOTAL *	STRAIN-ENERGY-DENSITY
2000	6.693402E+01	0.0346	2.319581E-02
3000	7.272415E+02	0.3762	2.524788E-01
4000	3.042442E+03	1.5740	5.154527E-01
5000	7.669977E+03	3.9680	1.850282E+00
6000	2.427930E+03	1.2561	1.063298E+00
7000	3.200997E+03	1.6560	8.289177E-01
8000	3.338734E+03	1.7273	1.102878E+00
9000	4.902207E+02	0.2536	1.829966E-01
10000	3.545786E+04	18.3438	5.140170E+00
11000	2.333120E+04	12.0702	2.131451E+00
12000	1.634373E+04	8.4553	1.578104E+00
13000	6.652102E+03	3.4414	8.818122E-01
14000	1.038806E+04	5.3742	2.758766E+00
15000	4.330408E+02	0.2240	7.113289E-01
16000	3.841328E+02	0.1987	6.310025E-01
17000	6.695837E+02	0.3464	2.511360E+01
18000	2.238049E+01	0.0116	2.511472E+01
19000	5.623860E+01	0.0291	1.714290E+01
20000	1.203364E+04	6.2255	1.010890E+00
21000	2.579918E+04	13.3470	9.563110E-01
22000	7.894949E+03	4.0844	7.137922E-01
23000	2.315073E+01	0.0120	1.142624E+01
27000	3.681078E+03	1.9044	
28000	2.916098E+04	15.0862	1.969896E+00
TYPE = BAR SUBTOTAL	1.932961E+05	100.0000	

FIGURE 2-19. MSC/NASTRAN ELEMENT STRAIN ENERGIES

2.3.2.10 Grid Point Force Balance

Figure 2-20 shows the NASTRAN output that tabulates all the forces and moments acting at the grid points. The totals shown at each grid point are not always zero; the loads due to RBAR rigid bar elements are not included in the balance. Therefore, mass points which have node points connected to them, as well as the corresponding node points, will show nonzero total loads. (Grid points 200 and 201 in figure 2-20 for example.) Mass points without node points (such as 500 or 600) will show zero total loads. Due to this anomaly in the grid point force balance output, these data are only marginally useful.

2.3.3 KRASH85 Output

2.3.3.1 Initial Output

The initial output of KRASH85 is identical to that of KRASHIC, described in Section 2.3.1. These data were illustrated in figures 2-8 through 2-10. The only exceptions to this are the mass and node point coordinates, as well as the initial mass and node point deflections. The values shown in the KRASHIC input represent the values before the last iteration of KRASHIC/MSCTRAN. The values shown in the KRASH85 output are those following the last iteration. There will be slight differences in the deflections between those two outputs, unless a very large number of iterations are used (>10).

Figure 2-21 shows this section of the output from KRASH85. Note that the initial deflections and corresponding coordinate positions are slightly different from those shown in figure 2-9. As an example, the initial node point z deflection for node point 11, 1 changes from -.3946611 in figure 2-9 to -.3946607 in figure 2-21. These values represent before and after the tenth iteration. The corresponding node point z coordinates show no difference between figures 2-9 and 2-21, since the coordinate values are shown only to .001 inch. The differences are much finer than that.

Also, the initial deflections are in data set XYZ.NASOUT.DATA, which is always shown at the botton of the ECHO of input data. If all deflections

in this data set agree between the KRASHIC and KRASH85 outputs, then further iterations cannot improve the accuracy of the initial conditions balance. If the two sets of data do differ, and the user is not satisfied with the quality of the initial balance, then further iterations could improve the initial balance.

KRASH85 includes some additional miscellaneous calculated data, in addition to that described for KRASHIC in Section 2.3.1.3. Figure 2-22 illustrates this output, which is calculated prior to time zero in KRASH85. These data include

- Beam uncoupled, undamped frequencies
- Beam damping constants
- Euler angles, beam IJ to airplane
- Load interaction curve load ratios (optional)

The beam frequencies output are the undamped, uncoupled individual beam frequencies associated with the six degrees of freedom of each beam. The frequencies listed under the headings (1), (2), and (3) correspond with the three translational degrees of freedom (x, y, z) and those listed under the heading (4), (5), and (6) correspond to the three rotational degrees of freedom (ϕ, θ, ψ). The frequencies are computed using equations 1-55(a) and 1-55(b) from Volume I, Section 1.3.5.3.6.

The frequency values summarized should be reviewed for indications of potential stability problems which may occur with the numerical integration routine used in the program. For example, high frequencies combined with a relatively coarse integration interval may result in numerical integration instabilities. In general, beam member frequencies should satisfy the following criteria:

1) Member frequencies $<$ 500 Hz

2) The product of the maximum beam member frequency and the integration interval <0.01

INITIAL CONDITION STATIC SOLUTION

G R I D   P O I N T   F O R C E   B A L A N C E

POINT-ID	ELEMENT-ID	SOURCE	T1	T2	T3	R1	R2	R3
100		APP-LOAD	-7.567860E+00	0.0	-7.223518E+02	0.0	7.487885E+01	0.0
100	1000	BAR	7.567859E+00	0.0	7.223516E+02	0.0	-7.487885E+01	0.0
100		*TOTALS*	-1.546141E-11	0.0	-1.746230E-10	0.0	-1.536682E-08	0.0
200		APP-LOAD	-3.155522E+01	0.0	-4.095044E+03	0.0	5.615913E+02	0.0
200	1000	BAR	-7.567859E+00	0.0	-7.223516E+02	0.0	-7.289244E+04	0.0
200	2000	BAR	4.346039E+01	0.0	5.419457E+03	0.0	7.469412E+04	0.0
200	23000	BAR	-3.308794E+00	0.0	-4.859561E+02	0.0	-9.780161E+01	0.0
200		*TOTALS*	1.028524E+00	0.0	1.161077E+02	0.0	2.265459E+03	0.0
201		APP-LOAD	-3.488073E+00	0.0	1.565496E+03	0.0	0.0	0.0
201	19000	BAR	2.459548E+00	0.0	-1.681604E+03	0.0	8.109880E+01	0.0
201		*TOTALS*	-1.028524E+00	0.0	-1.161077E+02	0.0	8.109880E+01	0.0
300		APP-LOAD	-2.299168E+01	0.0	-6.531187E+03	0.0	1.814595E+02	0.0
300	2000	BAR	-4.346039E+01	0.0	-5.419457E+03	0.0	-9.423384E+05	0.0
300	3000	BAR	6.645207E+01	0.0	1.195064E+04	0.0	9.421569E+05	0.0
300		*TOTALS*	-1.421085E-12	0.0	-2.473826E-10	0.0	7.683411E-09	0.0
400		APP-LOAD	5.847729E+00	0.0	-4.032344E+03	0.0	1.248885E+02	0.0
400	3000	BAR	-6.645207E+01	0.0	-1.195064E+04	0.0	-2.854471E+06	0.0
400	4000	BAR	6.060435E+01	0.0	1.598299E+04	0.0	2.854346E+06	0.0
400		*TOTALS*	2.785328E-12	0.0	-1.164153E-10	0.0	1.024455E-08	0.0
500		F-OF-SPC	9.535735E-06	1.102906E+05	-1.647945E-03	1.158149E+07	4.253135E-01	-2.487183E+06
500		APP-LOAD	7.060229E+01	0.0	-6.685789E+03	0.0	2.352506E+02	0.0
500	4000	BAR	-6.060435E+01	0.0	-1.598299E+04	0.0	-6.051349E+06	0.0
500	5000	BAR	-2.312483E+04	0.0	-1.505520E+04	0.0	8.780416E+06	0.0
500	10000	BAR	2.311484E+04	-1.102906E+05	3.772398E+04	-1.158149E+07	-2.729302E+06	2.487183E+06
500		*TOTALS*	1.546141E-11	1.455192E-11	-2.910383E-11	-6.984919E-10	-2.328306E-10	-1.396984E-09
600		APP-LOAD	4.233434E+01	0.0	-2.872200E+03	0.0	2.246365E+02	0.0
600		F-OF-SPC	0.0	-2.197132E+04	0.0	1.765277E+06	0.0	1.538706E+06
600	5000	BAR	2.312483E+04	0.0	1.505520E+04	0.0	-6.951579E+06	0.0
600	6000	BAR	-2.629875E+04	0.0	-1.814537E+04	0.0	7.071534E+06	0.0
600	20000	BAR	3.131584E+03	2.197132E+04	5.962367E+03	-1.765277E+06	-1.201791E+05	-1.538706E+06
600		*TOTALS*	-3.365130E-11	4.547474E-12	-3.883542E-10	-2.328306E-10	2.124580E-08	0.0
700		APP-LOAD	5.941232E+01	0.0	-3.344874E+03	0.0	2.620759E+02	0.0
700	6000	BAR	2.629875E+04	0.0	1.814537E+04	0.0	-5.497074E+06	0.0
700	7000	BAR	-2.635816E+04	0.0	-1.480050E+04	0.0	5.496812E+06	0.0
700		*TOTALS*	5.820766E-11	0.0	1.527951E-09	0.0	3.725290E-09	0.0
800		APP-LOAD	8.387946E+01	0.0	-4.482066E+03	0.0	3.369546E+02	0.0
800	7000	BAR	2.635816E+04	0.0	1.480050E+04	0.0	-3.567440E+06	0.0
800	8000	BAR	-2.644204E+04	0.0	-1.031843E+04	0.0	3.567104E+06	0.0
800		*TOTALS*	1.455192E-11	0.0	-4.947651E-10	0.0	7.078052E-08	0.0
900		F-OF-SPC	0.0	4.899299E+04	0.0	2.010931E+06	0.0	3.964869E+03
900		APP-LOAD	6.130714E+01	0.0	-2.573729E+03	0.0	7.822592E+01	0.0

FIGURE 2-20. MSC/NASTRAN GRID POINT FORCE BALANCE

2 1 -1.302763D-01 0.0 8.132805D-01

GENERALIZED SURFACE DATA

BETA = 0.0 DEGREES
XGIN = 0.0
ZGIN = 0.0

MASS DATA

	WEIGHTS	MASS COORDINATES F.S.,B.L.,W.L.			MASS MOMENTS OF INERTIA (LB-IN-SEC**2)			
I	W	X''	Y''	Z''	IX	IY	IZ	I
1	1.58500D 03	1.98969D 02	0.0	2.19007D 02	1.15140D 04	4.00000D 04	1.50000D 04	1
2	9.06450D 03	2.99972D 02	0.0	2.17933D 02	8.90800D 04	3.00000D 05	9.90000D 04	2
3	1.53181D 04	4.59992D 02	0.0	2.08278D 02	1.62780D 05	9.69350D 04	1.03090D 05	3
4	1.30960D 04	6.19996D 02	0.0	2.05853D 02	1.96270D 05	6.67150D 04	7.93890D 04	4
5	2.17526D 04	8.20000D 02	0.0	2.00200D 02	4.91060D 05	1.25670D 05	1.46510D 05	5
6	7.90150D 03	9.60000D 02	0.0	2.12260D 02	8.13830D 04	1.20000D 05	2.00000D 05	6
7	9.19070D 03	1.03998D 03	0.0	2.07578D 02	8.75360D 04	1.40000D 05	2.00000D 05	7
8	9.93840D 03	1.20002D 03	0.0	2.24243D 02	8.80980D 04	1.80000D 05	3.00000D 05	8
9	5.70200D 03	1.36006D 03	0.0	2.58354D 02	9.62490D 04	4.17880D 04	2.60390D 04	9
10	6.17520D 03	1.57041D 03	0.0	2.99352D 02	2.15300D 05	1.07980D 05	1.58630D 05	10
11	9.67060D 03	8.01276D 02	1.18362D 02	1.88755D 02	1.52130D 04	1.38580D 05	3.60000D 05	11
12	1.00656D 04	8.52082D 02	2.71759D 02	2.05442D 02	1.95100D 04	1.22630D 05	3.00000D 05	12
13	5.28650D 03	9.42899D 02	4.30395D 02	2.26070D 02	7.27150D 03	5.26190D 04	1.10000D 05	13
14	3.75900D 03	1.04443D 03	5.82860D 02	2.54346D 02	4.40830D 03	2.58230D 04	6.00000D 04	14
15	1.54230D 03	1.11010D 03	7.40166D 02	2.69696D 02	1.67080D 03	9.01370D 03	1.80000D 04	15
16	5.40000D 03	7.19079D 02	3.21889D 02	1.67738D 02	3.65156D 03	2.57460D 04	2.93746D 04	16
17	5.15100D 03	9.02105D 02	5.51635D 02	1.96935D 02	3.71200D 03	2.45882D 04	2.81780D 04	17
18	1.92200D 03	8.87183D 02	1.32363D 02	9.13225D 01	3.71000D 02	1.60000D 03	2.00000D 03	18
19	2.38000D 02	2.79270D 02	0.0	8.41201D 01	2.40000D 01	3.00000D 02	5.00000D 02	19
20	1.00000D 03	2.99902D 02	0.0	2.37838D 02	1.00000D 03	1.00000D 03	1.00000D 03	20
21	1.00000D 03	2.99927D 02	0.0	2.37933D 02	1.00000D 03	1.00000D 03	1.00000D 03	21

NODE POINT DATA

MASS	N.P.	NODE POINT COORDINATES F.S.,B.L.,W.L.		
I	M	X''	Y''	Z''
5	1	7.75100D 02	4.80000D 01	1.81000D 02
11	1	7.73881D 02	1.18360D 02	1.86695D 02
11	2	8.86987D 02	1.31766D 02	1.80433D 02
11	3	8.86987D 02	1.31766D 02	1.80433D 02
12	1	8.11556D 02	3.21562D 02	2.02322D 02
14	1	9.93477D 02	5.51310D 02	2.30161D 02
15	1	1.14545D 03	7.40228D 02	2.76217D 02
15	2	1.11010D 03	7.40166D 02	2.69696D 02
16	1	7.35461D 02	3.21475D 02	2.01686D 02
16	2	7.19079D 02	3.21889D 02	1.67738D 02
17	1	9.17386D 02	5.50900D 02	2.29468D 02
2	1	2.79130D 02	0.0	1.46687D 02

:
EXTERNAL SPRING DATA

FIGURE 2-21. KRASH85 OUTPUT, INITIAL MASS/NODE POINT DEFLECTIONS (SHEET 1 OF 2)

NO MASS POSITION PLOTS

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

XGDOT P' PHI'	YGDOT Q' THETA'	ZGDOT R' PSI'
3.14000D 03	0.0	3.00000D 02
0.0	1.00000D-01	0.0
0.0	1.74500D-02	0.0

INITIAL MASS POINT DEFLECTIONS

I	DXAP(I)	DYAP(I)	DZAP(I)	DPHAP(I)	DTHAP(I)	DPSAP(I)	I
1	3.089143D-02	0.0	9.927106D-01	0.0	-2.240265D-03	0.0	1
2	2.848941D-02	0.0	7.668377D-01	0.0	-2.228401D-03	0.0	2
3	7.956203D-03	0.0	4.223564D-01	0.0	-2.016658D-03	0.0	3
4	3.881565D-03	0.0	1.467094D-01	0.0	-1.310210D-03	0.0	4
5	0.0	0.0	0.0	0.0	0.0	0.0	5
6	-3.899802D-04	0.0	1.395649D-01	0.0	1.905725D-03	0.0	6
7	1.741050D-02	0.0	3.224221D-01	0.0	2.646156D-03	0.0	7
8	-1.960022D-02	0.0	8.574673D-01	0.0	3.925506D-03	0.0	8
9	-1.623366D-01	0.0	1.646018D 00	0.0	5.791202D-03	0.0	9
10	-4.121324D-01	0.0	2.947553D 00	0.0	6.380439D-03	0.0	10
11	2.376698D-02	-6.204827D-02	-4.549806D-01	6.692734D-03	-2.201433D-03	5.605535D-04	11
12	2.183176D-01	4.138304D-02	-2.341775D 00	1.306023D-02	-6.671559D-03	9.325789D-04	12
13	6.008078D-01	3.054584D-01	-6.170222D 00	2.241259D-02	-1.032131D-02	1.681531D-03	13
14	1.368588D 00	6.399867D-01	-1.084582D 01	2.562689D-02	-7.394198D-03	5.296092D-03	14
15	2.495204D 00	4.342735D-01	-1.459584D 01	1.709927D-02	-9.067751D-03	4.925180D-03	15
16	-7.919782D-02	-2.893808D-01	-1.937816D 00	1.295898D-02	-9.379067D-03	1.573276D-03	16
17	6.952541D-01	-3.463942D-02	-8.834657D 00	2.537073D-02	-9.936508D-03	5.952671D-03	17
18	-1.832867D-01	-7.628582D-01	-6.224991D-01	6.689236D-03	-2.204064D-03	5.605265D-04	18
19	-2.696309D-01	0.0	8.798568D-01	0.0	-2.223161D-03	0.0	19
20	9.809846D-02	0.0	8.621072D-01	0.0	-4.137866D-03	0.0	20
21	7.305723D-02	0.0	7.669372D-01	0.0	-2.228401D-03	0.0	21

INITIAL NODE POINT DEFLECTIONS

I	M	DXNPAP	DYNPAP	DZNPAP
5	1	0.0	0.0	0.0
11	1	1.923044D-02	-6.048078D-02	-3.946607D-01
11	2	1.296102D-02	-1.657880D-01	-7.333746D-01
11	3	1.296102D-02	-1.657880D-01	-7.333746D-01
12	1	2.439480D-01	3.842933D-02	-2.721844D 00
14	1	1.022665D 00	2.900504D-01	-9.660528D 00
15	1	2.554648D 00	3.717274D-01	-1.491737D 01
15	2	2.495204D 00	4.342735D-01	-1.459584D 01
16	1	2.385539D-01	1.247806D-01	-2.086101D 00
16	2	-7.919782D-02	-2.893808D-01	-1.937816D 00
17	1	1.014149D 00	6.997894D-01	-8.967865D 00

FIGURE 2-21. KRASH85 OUTPUT, INITIAL MASS/NODE POINT DEFLECTIONS (SHEET 2 OF 2)

	-4.93617D 01	-1.64513D 01	4.78414D 03	2.29264D 02	9.18383D 01	9.96840D 03
	-9.34168D-03	-7.76185D-04	2.08112D-02	-2.21321D-04	-3.72978D-03	-2.38454D-04
18	-3.35372D 01	0.0	1.92171D 03	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	1.97453D 01	0.0	-3.54470D 01	2.42191D-02	5.99038D 00	-1.68548D-02
	-1.37919D 01	0.0	1.88626D 03	2.42191D-02	5.99038D 00	-1.68548D-02
	-1.02326D-02	1.29277D-04	1.84649D-02	-2.09858D-06	-3.74386D-03	2.50486D-05
19	-4.15289D 00	0.0	2.37964D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	6.20994D 00	0.0	-5.74830D 00	0.0	1.12318D 00	0.0
	2.05706D 00	0.0	2.32215D 02	0.0	1.12318D 00	0.0
	-2.60384D-02	0.0	2.42105D-02	0.0	-3.74395D-03	0.0
20	-1.74491D 01	0.0	9.99848D 02	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	2.40667D 01	0.0	-2.79347D 01	0.0	3.74395D 00	0.0
	6.61761D 00	0.0	9.71913D 02	0.0	3.74395D 00	0.0
	-2.39509D-02	0.0	2.80341D-02	0.0	-3.74395D-03	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0

BEAM UNCOUPLED,UNDAMPED FREQUENCIES (CPS)

IJ	I	J	M	N	(1)	(2)	(3)	(4)	(5)	(6)
1	1	2	0	0	1.5153D 02	1.7671D 02	2.2874D 02	9.6189D 01	1.3274D 02	1.6880D 02
2	2	3	0	0	6.2094D 01	4.6372D 01	6.2054D 01	3.5380D 01	8.1503D 01	7.3325D 01
3	3	4	0	0	5.5817D 01	4.1760D 01	5.9058D 01	2.9532D 01	1.1739D 02	7.7902D 01
4	4	5	0	0	5.9388D 01	2.8866D 01	4.9366D 01	2.5029D 01	1.2571D 02	6.7576D 01
5	5	6	0	0	8.4160D 01	5.8245D 01	9.1995D 01	3.9755D 01	1.1673D 02	6.2719D 01
6	6	7	0	0	1.2795D 02	1.7495D 02	2.7023D 02	7.3988D 01	1.6315D 02	8.4980D 01
7	7	8	0	0	7.8157D 01	6.0474D 01	8.2003D 01	4.8460D 01	9.5476D 01	5.7242D 01
8	8	9	0	0	7.8113D 01	4.9757D 01	6.4332D 01	3.3242D 01	1.0111D 02	8.8339D 01
9	9	10	0	0	6.2027D 01	1.9545D 01	6.0157D 01	2.6221D 01	1.1884D 02	4.2904D 01
10	5	11	0	1	7.8575D 01	9.7901D 01	3.6562D 01	2.2297D 01	6.5550D 01	9.3224D 01
11	11	12	1	0	8.5052D 01	6.8340D 01	2.2847D 01	1.6286D 01	5.7183D 01	6.0580D 01
12	12	13	0	0	9.2917D 01	5.6161D 01	1.5987D 01	1.3332D 01	4.4400D 01	6.3168D 01
13	13	14	0	0	9.8858D 01	4.1969D 01	1.2952D 01	1.3725D 01	3.8719D 01	5.4686D 01
14	14	15	0	1	9.7455D 01	3.5862D 01	1.3889D 01	1.6384D 01	4.7736D 01	5.5927D 01
15	12	16	1	1	5.5416D 01	8.9189D 00	2.4131D 01	9.6769D 00	2.1944D 01	7.2341D 00
16	14	17	1	1	7.0474D 01	1.1343D 01	3.0688D 01	1.2004D 01	2.8512D 01	8.5438D 00
17	11	18	2	0	4.5310D 00	2.7229D 01	2.7229D 01	1.5356D 01	7.1791D 01	1.5003D 02
18	11	18	3	0	4.5310D 00	2.7229D 01	2.7229D 01	1.5356D 01	7.1791D 01	1.5003D 02
19	2	19	1	0	1.4218D 01	4.4878D 01	4.4878D 01	6.6902D 00	7.2583D 01	2.5653D 02
20	6	12	0	0	5.5440D 01	1.4915D 01	4.6029D 00	5.3174D 00	1.6932D 01	2.4627D 01
21	9	14	0	0	5.1478D 01	6.1110D 00	1.8859D 00	6.7777D 00	1.9219D 01	4.2045D 01
22	12	0	0	0	3.8142D 01	5.5219D 00	1.7041D 00	3.7230D 00	1.9544D 01	1.6156D 01
23	2	20	0	0	1.0537D 01	4.0643D 00	4.0643D 00	7.1706D-01	2.2599D 00	2.2688D 00
24	2	21	0	0	8.4297D 00	4.0354D 00	4.0354D 00	7.1535D-01	2.2545D 00	2.2634D 00
25	15	16	0	0	5.2941D 01	0.0	0.0	0.0	0.0	0.0
26	15	16	2	2	5.2941D 01	0.0	0.0	0.0	0.0	0.0

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 1 OF 3)

27	15	0	0	0	4.13890 01	1.93710 00	7.50220-01	6.24050 00	3.13410 01	2.46680 01
28	15	0	2	0	4.13890 01	1.93710 00	7.50220-01	6.24050 00	3.13410 01	2.46680 01

DAMPING TERMS (LB/IN/SEC,TRANSLATIONS (1)-(3) AND LB-IN-SEC,ROTATIONS (4)-(6))

IJ	I	J	M	N	(1)	(2)	(3)	(4)	(5)	(6)
1	1	2	0	0	1.05034D-04	9.00681D-05	6.95787D-05	1.65461D-04	1.19896D-04	9.42867D-05
2	2	3	0	0	2.563140-04	3.432130-04	2.56479D-04	4.49845D-04	1.95276D-04	2.17053D-04
3	3	4	0	0	2.851350-04	3.81116D-04	2.69490D-04	5.38921D-04	1.355830-04	2.04302D-04
4	4	5	0	0	2.67990D-04	5.51365D-04	3.22401D-04	6.35885D-04	1.26604D-04	2.35521D-04
5	5	6	0	0	1.89111D-04	2.73250D-04	1.73004D-04	4.00342D-04	1.36345D-04	2.53759D-04
6	6	7	0	0	1.24385D-04	9.09731D-05	5.88954D-05	2.15110D-04	9.75521D-05	1.87286D-04
7	7	8	0	0	2.03635D-04	2.63177D-04	1.94085D-04	3.28423D-04	1.66696D-04	2.78039D-04
8	8	9	0	0	2.03749D-04	3.19864D-04	2.47397D-04	4.78775D-04	1.57402D-04	1.80165D-04
9	9	10	0	0	2.56589D-04	8.14317D-04	2.64566D-04	6.06964D-04	1.33923D-04	3.70956D-04
10	5	11	0	1	2.02552D-04	1.62567D-04	4.35297D-04	7.13786D-04	2.42798D-04	1.70722D-04
11	11	12	1	0	1.87126D-04	2.32888D-04	6.96619D-04	9.77254D-04	2.78325D-04	2.62719D-04
12	12	13	0	0	1.71287D-04	2.83388D-04	9.95514D-04	1.19376D-03	3.58461D-04	2.51954D-04
13	13	14	0	0	1.60993D-04	3.79222D-04	1.22882D-03	1.15964D-03	4.11048D-04	2.91034D-04
14	14	15	0	1	1.63311D-04	4.43797D-04	1.14588D-03	9.71391D-04	3.33405D-04	2.84579D-04
15	12	16	1	1	2.87200D-04	1.78447D-03	6.59558D-04	1.64468D-03	7.25262D-04	2.20006D-03
16	14	17	1	1	2.25834D-04	1.40315D-03	5.18620D-04	1.32582D-03	5.58197D-04	1.86282D-03
17	11	18	2	0	3.51261D-03	5.84496D-04	5.84496D-04	1.03643D-03	2.21691D-04	1.06081D-04
18	11	18	3	0	3.51261D-03	5.84496D-04	5.84496D-04	1.03643D-03	2.21691D-04	1.06081D-04
19	2	19	1	0	1.11938D-03	3.54641D-04	3.54641D-04	2.37893D-03	2.19272D-04	6.20421D-05
20	6	12	0	0	2.87074D-04	1.06706D-03	3.45768D-03	2.99307D-03	9.39985D-04	6.46257D-04
21	9	14	0	0	3.09170D-04	2.60439D-03	8.43919D-03	2.34821D-03	8.28098D-04	3.78532D-04
22	12	0	0	0	4.17273D-04	2.88224D-03	9.33954D-03	4.27495D-03	8.14357D-04	9.85103D-04
23	2	20	0	0	9.54928D-03	2.47574D-02	2.47574D-02	1.40327D-01	4.45248D-02	4.43507D-02
24	2	21	0	0	8.75355D-03	1.82857D-02	1.82857D-02	1.03152D-01	3.27294D-02	3.26015D-02
25	15	16	0	0	3.00629D-04	0.0	0.0	0.0	0.0	0.0
26	15	16	2	2	3.00629D-04	0.0	0.0	0.0	0.0	0.0
27	15	0	0	0	3.84539D-04	8.21634D-03	2.12145D-02	2.55036D-03	5.07811D-04	6.45175D-04
28	15	0	2	0	3.84539D-04	8.21634D-03	2.12145D-02	2.55036D-03	5.07811D-04	6.45175D-04

EULER ANGLES, BEAM IJ TO AIRPLANE (RADIANS)

IJ	I	J	M	N	THEIJO(IJ)	PSIIJO(IJ)
1	1	2	0	0	-1.06343D-02	3.14159D 00
2	2	3	0	0	-6.02662D-02	3.14159D 00
3	3	4	0	0	-1.51507D-02	3.14159D 00
4	4	5	0	0	-2.82584D-02	3.14159D 00
5	5	6	0	0	8.59336D-02	3.14159D 00
6	6	7	0	0	-5.84820D-02	3.14159D 00
7	7	8	0	0	1.03758D-01	3.14159D 00
8	8	9	0	0	2.09997D-01	3.14159D 00
9	9	10	0	0	1.92493D-01	3.14159D 00
10	5	11	0	1	-1.05920D-01	-1.19924D 00
11	11	12	1	0	1.08453D-01	-2.04225D 00
12	12	13	0	0	1.12376D-01	-2.09074D 00
13	13	14	0	0	1.53152D-01	-2.15829D 00
14	14	15	0	1	1.16432D-01	-2.14145D 00
15	12	16	1	1	-8.35444D-03	1.13479D-03
16	14	17	1	1	-9.10265D-03	5.38477D-03
17	11	18	2	0	2.20223D-03	-3.13489D 00
18	11	18	3	0	2.20223D-03	-3.13489D 00
19	2	19	1	0	2.22730D-03	3.14159D 00
20	6	12	0	0	-2.33152D-02	-1.19278D 00
21	9	14	0	0	-6.04694D-03	-1.07449D 00
22	12	0	0	0	0.0	1.57080D 00
23	2	20	0	0	-3.49710D-03	0.0
24	2	21	0	0	-2.22840D-03	0.0

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 2 OF 3)

25	15	[illegible]	0	0	-1.76219D-01	8.19057D-01
26	15	16	2	2	-1.76219D-01	8.19057D-01
27	15	0	0	0	0.0	1.57080D 00
28	15	0	2	0	0.0	1.57080D 00

LOAD INTERACTION CURVE LOAD RATIOS

CURVE NO.	BEAM NO.	PROPORTION OF BEAM END LOADS MAKING UP INTERACTION LOADS I END	J END
1	1	-2.8207D-04	1.0003D 00
2	2	9.9982D-01	1.7804D-04
3	2	3.7490D-01	6.2510D-01
4	3	8.7495D-01	1.2505D-01
5	3	4.9996D-01	5.0004D-01
6	3	-2.4259D-05	1.0000D 00
7	4	9.9998D-01	1.9407D-05
8	5	2.7856D-06	1.0000D 00
9	6	1.0000D 00	-4.8758D-06
10	6	4.9989D-01	5.0011D-01
11	7	7.4995D-01	2.5005D-01
12	7	2.5006D-01	7.4994D-01
13	8	7.5019D-01	2.4981D-01
14	8	2.5032D-01	7.4968D-01
15	9	8.1014D-01	1.8986D-01

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 3 OF 3)

While these criteria are suggested as guidelines, their exceedance does not necessarily mean that instability problems will automatically occur.

Beam structural damping coefficients are computed within the program for each of the six beam degrees of freedom. The damping coefficients are computed from equations (1-54), Section 1.3.5.3.6, Volume I.

These damping coefficients are printed only to provide a record of the actual data used in the calculations. The interpretation of the proper damping values should be based upon inspection of the damping ratios (actual damping/critical damping) summarized in the section entitled "INTERNAL BEAM DATA" (Section (2.3.3.2.2)). For typical aircraft constructions, damping ratios in the range of .01 to .10 are appropriate. Higher values should be used only to represent mechanical damping devices, such as hydraulic or friction dampers in landing gears or viscoelastic engine mounts. Values greater than .05 are probably only justified as representative of the friction damping associated with relative motions of riveted and bolted structure under conditions of severe loading and deformation.

The Euler angles define the initial orientation of the beam axes relative to the airplane, according to the convention shown in figure 2-5. These angles should be interpreted in the following manner. Assume the beam axes are oriented such that x is forward, y to the right and z down. Then rotate PSIIJO radians about the z axis, positive nose right, forming a new set of x' and y' axes. Then rotate THEIJO radians about the new y' axis, positive nose up. This final position defines the orientation of the beam axes with respect to the airplane. For vertical beams, which are denoted by VBM=1 in the beam data formatted output, the above procedure is followed with one exception. The initial orientation is such that the x axis is positive up, y axis positive right and z axis positive forward.

It should be noted that during the time history analysis, these angles vary with time and are part of the print output. Any question regarding the current beam orientations should be resolved by examining the current values of the beam orientation Euler angles. These are interpreted the same as the preceding discussion, except that the initial starting orientation is the

ground axes rather than the airplane axes. Since the initial attitude of the vehicle may not be parallel to the ground axes (generally it is not), the time zero value of the beam orientation Euler angles may differ from the angles listed in the MODEL PARAMETERS section of the output. The latter is provided as a definition of beam axes orientations that is independent of vehicle initial conditions (and hence represents a true model parameter), whereas the time varying values represent the actual beam orientation during the analysis.

The load interaction curve load ratios tabulate what proportion of the I and J end beam loads are used to calculate the intermediate loads at the location specified for each load interaction curve.

2.3.3.2 Time History Output

This section of the output prints the time varying response quantities at each print time interval, including time zero. This output consists of the following groups of data:

- Title cards
- Analysis time
- Mass and node point displacements, velocities and accelerations in six directions for all NM lumped masses and NNP node points, in mass axes and ground axes
- Mass impulses (G-sec) based on filtered accelerations
- Internal beam strain forces, total forces (strain + damping) in both beam and mass axes and displacements in six directions for all NB internal beams
- External spring compressions, ground deflections, axial loads, and ground contact loads (3 directions) in ground axes and mass axes for all NSP external springs
- DRI number for all DRI beam elements
- Overall vehicle c.g. translational velocity (3 directions)
- Volume change data, including current volume, current volume/initial volume, and the changes in length of the three lengths of the volume (optional)

- Energy distribution by type

- Energy distribution by mass (kinetic and potential), beam (strain, damping) and spring (crushing, friction)

- Mass energy deviation

- Stress output for internal beam elements, including ratios of current stress/failure stress for two failure theories

- At t=0 only, the differences between actual initial mass accelerations and the theoretically exact values, for all NM masses.

- Mass location plot (time=0 and at specified intervals)

Figure 2-23 illustrates a portion of this output for the sample case, for one typical cut in time. It should be noted that all this output is in inch, pound, second and radian units except XACCEL, YACCEL and ZACCEL. These are in g's. A more detailed description of the specific items printed out at each time follows.

2.3.3.2.1 Mass and Node Point Data. - X, Y and Z are the ground coordinates of mass I or node point I, M. The data for each node point are printed below the data for the mass to which they are attached. XDOT, YDOT and ZDOT are the ground axes components of the translational velocity of mass I or node point I, M. U, V and W are the corresponding components in mass fixed axes. UDOT, VDOT and WDOT (not printed for the node points) are the time derivatives of U, V and W. Note that these are not the translational acceleration components, but are used in Euler's equations of motion. XACCEL, YACCEL and ZACCEL are the body-fixed-axes components of the translational accelerations of mass I or node point I, M, in g units. XACFIL, YACFIL and ZACFIL are the same accelerations after passing through a first order filter with an input cutoff frequency. All the above quantities are positive forward, right and down.

PHI, THETA and PSI are the Euler angles defining the orientations of mass I with respect to the ground. These are positive right-wing-down, nose-up and nose-right, respectively. PHIDOT, THETADOT and PSIDOT are the time derivatives of the same angles. P, Q and R are the body axes components of

LT.SAMPLE.DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

TIME = 0.050000 NUMBER OF INTEGRATION INTERVALS = 200

MASS DISPLACEMENTS,VELOCITIES,AND ACCELERATIONS

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT XACFIL	THETA THETADOT Q QDOT YACFIL	PSI PSIDOT R RDOT ZACFIL
MASS 1	8.00733D 02	0.0	-1.47442D 02	0.0	1.99344D-02	0.0
	3.12727D 03	0.0	2.42624D 02	0.0	4.22122D-02	0.0
	3.12181D 03	0.0	3.04912D 02	0.0	4.22122D-02	0.0
	-8.02949D 02	0.0	3.04496D 02	0.0	-2.25872D 00	0.0
	-2.04683D 00	0.0	4.47455D-01	-2.09191D 00	0.0	5.90159D-01
MASS 2	6.99778D 02	0.0	-1.44129D 02	0.0	1.99257D-02	0.0
	3.12748D 03	0.0	2.47309D 02	0.0	5.09840D-02	0.0
	3.12193D 03	0.0	3.09573D 02	0.0	5.09840D-02	0.0
	-7.89332D 02	0.0	1.16746D 02	0.0	-1.99716D 00	0.0
	-2.00401D 00	0.0	-1.09904D-01	-2.06380D 00	0.0	-3.36351D-01
NODE 1	7.22192D 02	0.0	-7.33622D 01			
	3.13109D 03	0.0	2.46166D 02			
	3.12556D 03	0.0	3.08503D 02			
	-2.37254D 00	0.0	-1.73019D-03	-2.59084D 00	0.0	-1.81651D-01
MASS 3	5.40001D 02	0.0	-1.30965D 02	0.0	1.95106D-02	0.0
	3.12910D 03	0.0	2.57322D 02	0.0	6.14072D-02	0.0
	3.12348D 03	0.0	3.18320D 02	0.0	6.14072D-02	0.0
	-6.44915D 02	0.0	-2.40675D 02	0.0	-3.72638D 00	0.0
	-1.62012D 00	0.0	-1.12041D 00	-1.70710D 00	0.0	-9.77880D-01
MASS 4	3.80066D 02	0.0	-1.25204D 02	0.0	1.87936D-02	0.0
	3.13064D 03	0.0	2.61274D 02	0.0	-1.53279D-02	0.0
	3.12517D 03	0.0	3.20060D 02	0.0	-1.53279D-02	0.0
	-3.67004D 02	0.0	-1.34866D 03	0.0	-4.68099D 00	0.0
	-9.63496D-01	0.0	-3.36983D 00	-1.00582D 00	0.0	-2.20052D 00
MASS 5	1.80194D 02	0.0	-1.15644D 02	0.0	1.90969D-02	0.0
	3.13157D 03	0.0	2.54926D 02	0.0	-2.63228D-02	0.0
	3.12613D 03	0.0	3.14679D 02	0.0	-2.63228D-02	0.0
	-1.21743D 02	0.0	-1.88046D 03	0.0	6.69759D-01	0.0
	-3.36854D-01	0.0	-4.65848D 00	-4.37243D-01	0.0	-3.73706D 00
NODE 1	2.25452D 02	-4.80000D 01	-9.73046D 01			
	3.13108D 03	0.0	2.56118D 02			
	3.12562D 03	0.0	3.15861D 02			
	-3.03620D-01	0.0	-4.73642D 00	-4.46573D-01	0.0	-3.71546D 00
MASS 6	3.99989D 01	0.0	-1.24717D 02	0.0	2.50095D-02	0.0
	3.13100D 03	0.0	2.60638D 02	0.0	9.10641D-02	0.0
	3.12351D 03	0.0	3.38853D 02	0.0	9.10641D-02	0.0
	-2.97958D 02	0.0	-1.18411D 03	0.0	3.48013D 00	0.0
	-6.91971D-01	0.0	-3.80452D 00	-8.22834D-01	0.0	-3.03332D 00

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 1 OF 11)

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LT.SAMPLE.DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

TIME = 0.050000      NUMBER OF INTEGRATION INTERVALS = 200

MASS DISPLACEMENTS,VELOCITIES,AND ACCELERATIONS

                  X             Y             Z            PHI          THETA          PSI
                XDOT          YDOT          ZDOT         PHIDOT       THETADOT       PSIDOT
                  U             V             W             P             Q             R
                UDOT          VDOT          WDOT          PDOT          QDOT          RDOT
               XACCEL        YACCEL        ZACCEL        XACFIL        YACFIL        ZACFIL

MASS  7     -3.98394D 01   0.0          -1.18139D 02   0.0           2.68814D-02   0.0
             3.13128D 03   0.0           2.68794D 02   0.0           1.09835D-01   0.0
             3.12292D 03   0.0           3.52860D 02   0.0           1.09835D-01   0.0
            -3.82726D 02   0.0          -9.35405D 02   0.0           9.95340D-01   0.0
            -8.91112D-01   0.0          -3.31195D 00  -1.05350D 00   0.0          -2.87459D 00

MASS  8     -2.00215D 02   0.0          -1.30811D 02   0.0           2.91838D-02   0.0
             3.12917D 03   0.0           2.89501D 02   0.0           1.49132D-01   0.0
             3.11939D 03   0.0           3.80686D 02   0.0           1.49132D-01   0.0
            -4.00577D 02   0.0          -1.67921D 03   0.0          -1.05738D 01   0.0
            -8.90686D-01   0.0          -5.55547D 00  -1.13965D 00   0.0          -5.73759D 00

MASS  9     -3.61024D 02   0.0          -1.60932D 02   0.0           2.99974D-02   0.0
             3.12268D 03   0.0           3.23403D 02   0.0           2.68325D-01   0.0
             3.11157D 03   0.0           4.16916D 02   0.0           2.68325D-01   0.0
            -4.44561D 02   0.0          -2.12799D 03   0.0           5.15932D 00   0.0
            -8.61895D-01   0.0          -7.67591D 00  -1.33888D 00   0.0          -7.12321D 00

MASS 10     -5.72270D 02   0.0          -1.96934D 02   0.0           2.96380D-02   0.0
             3.11050D 03   0.0           3.86175D 02   0.0           3.15401D-01   0.0
             3.09769D 03   0.0           4.78181D 02   0.0           3.15401D-01   0.0
            -1.46931D 03   0.0           1.38234D 03   0.0           2.62217D 01   0.0
            -3.41579D 00   0.0           1.05008D 00  -3.83348D 00   0.0           1.42681D 00

MASS 11      1.99035D 02  -1.18350D 02  -1.04812D 02   7.37477D-03  -7.02830D-04   5.49534D-04
             3.13039D 03  -2.05098D-01   2.41493D 02   6.02192D-02  -4.80804D-01   1.21820D-02
             3.13056D 03  -1.60582D-01   2.39301D 02   6.02274D-02  -4.80701D-01   1.57275D-02
             1.22828D 02  -9.36457D 01  -3.41354D 03   1.35749D 00   2.73026D 00   8.04528D-01
             2.02023D-02  -1.52390D-01  -4.94477D 00  -1.45841D-01  -3.04430D-01  -5.59128D 00

  NODE 1     2.26434D 02  -1.18350D 02  -1.02792D 02
             3.12942D 03   7.70012D-03   2.54666D 02
             3.12960D 03   1.49892D-01   2.52472D 02
             1.79348D-02  -1.04409D-01  -5.13973D 00  -1.70865D-01  -2.56528D-01  -5.46954D 00

  NODE 2     1.13337D 02  -1.31759D 02  -9.63707D 01
             3.12650D 03  -1.76324D 00   1.99481D 02
             3.12664D 03  -2.02635D 00   1.97304D 02
             1.61123D-01  -3.54861D-01  -4.39054D 00  -9.49788D-02  -6.76767D-01  -6.17975D 00

  NODE 3     1.13337D 02  -1.31759D 02  -9.63707D 01
             3.12650D 03  -1.76324D 00   1.99481D 02
             3.12664D 03  -2.02635D 00   1.97304D 02
             1.61123D-01  -3.54861D-01  -4.39054D 00  -9.49788D-02  -6.76767D-01  -6.17975D 00

MASS 12      1.48075D 02  -2.71777D 02  -1.20343D 02   6.52104D-03   5.80848D-03   6.55330D-04
             3.13390D 03  -5.13986D-01   2.47087D 02  -3.42235D-01  -3.90598D-01  -5.08267D-02
```

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 2 OF 11)

	3.13241D 03	-8.37753D-01	2.65297D 02	-3.41940D-01	-3.90922D-01	-4.82777D-02
	-1.81794D 02	3.33001D 01	-3.05037D 03	-5.03209D 00	5.78854D 00	-2.78703D 00
	-7.39754D-01	-7.04915D-02	-4.72943D 00	-8.31290D-01	-1.67644D-01	-4.40509D 00
NODE 1	1.88624D 02	-3.21572D 02	-1.17403D 02			
	3.13032D 03	-1.48885D 00	2.79963D 02			
	3.12864D 03	-1.59600D 00	2.98158D 02			
	-1.08020D 00	-2.87691D-01	-4.69070D 00	-1.39422D 00	-4.53750D-01	-2.67885D 00

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 3 OF 11)

LT.SAMPLE.DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

TIME = 0.050000   NUMBER OF INTEGRATION INTERVALS = 200

MASS DISPLACEMENTS,VELOCITIES,AND ACCELERATIONS

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT XACFIL	THETA THETADOT Q QDOT YACFIL	PSI PSIDOT R RDOT ZACFIL
MASS 13	5.68609D 01	-4.30516D 02	-1.38101D 02	1.46830D-02	9.56579D-03	9.94485D-04
	3.13233D 03	-2.66183D 00	2.78435D 02	-3.30598D-01	-1.12590D-01	-3.29212D-02
	3.12952D 03	-1.24842D 00	3.08437D 02	-3.30283D-01	-1.13062D-01	-3.12630D-02
	-7.19873D 02	1.41329D 02	-2.52929D 03	-4.44241D 00	-1.32356D 01	-2.11951D 00
	-1.95540D 00	3.76586D-01	-5.63484D 00	-1.70504D 00	1.96309D-01	-5.68715D 00
MASS 14	-4.53884D 01	-5.82934D 02	-1.63826D 02	2.52866D-02	1.44151D-02	4.13714D-03
	3.12414D 03	-4.20851D 00	3.25967D 02	-1.54595D-01	4.14384D-02	-7.59635D-02
	3.11908D 03	-7.74854D 00	3.71280D 02	-1.53500D-01	3.95047D-02	-7.69790D-02
	-9.17819D 02	-2.01204D 01	2.34639D 02	-1.52956D 01	-4.72064D 00	-1.26272D 00
	-2.34132D 00	-5.26508D-01	2.91737D-01	-1.99936D 00	-6.86141D-01	4.86455D-01
NODE 1	6.11726D 00	-5.51433D 02	-1.40772D 02			
	3.12741D 03	-4.43869D 00	3.18991D 02			
	3.12244D 03	-8.16732D 00	3.64360D 02			
	-2.51907D 00	2.13545D-01	-3.44339D-01	-2.04552D 00	-9.33042D-02	-2.38063D-01
MASS 15	-1.11481D 02	-7.40176D 02	-1.77794D 02	1.77534D-02	1.34372D-02	4.67595D-03
	3.11651D 03	-6.43979D-01	3.25578D 02	7.86632D-02	7.82882D-02	-2.52688D-02
	3.11181D 03	-8.69146D 00	3.67636D 02	7.90028D-02	7.78274D-02	-2.66524D-02
	-1.05577D 03	-1.23406D 02	5.21904D 02	3.27123D 00	-4.75940D 00	-1.46156D-01
	-2.66163D 00	-6.09812D-01	7.22884D-01	-2.38896D 00	-5.68097D-01	3.61198D-01
NODE 1	-1.46960D 02	-7.40226D 02	-1.83518D 02			
	3.11606D 03	7.38190D-01	3.28365D 02			
	3.11133D 03	-7.25806D 00	3.70391D 02			
	-2.58450D 00	-5.44381D-01	2.86860D-01	-2.33163D 00	-4.51947D-01	3.90869D-02
NODE 2	-1.11481D 02	-7.40176D 02	-1.77794D 02			
	3.11651D 03	-6.43978D-01	3.25578D 02			
	3.11181D 03	-8.69146D 00	3.67636D 02			
	-2.66163D 00	-6.09812D-01	7.22884D-01	-2.38896D 00	-5.68097D-01	3.61198D-01
MASS 16	2.81845D 02	-3.21872D 02	-8.45587D 01	-7.57106D-02	4.69176D-02	5.40620D-02
	3.13459D 03	1.43295D 00	2.96776D 02	-8.00393D-02	9.60624D-02	-3.57953D-02
	3.11273D 03	-2.00995D 02	4.29279D 02	-7.83605D-02	9.84917D-02	-2.83874D-02
	-3.63580D 02	2.18718D 01	1.15656D 03	-1.45165D 01	-7.03121D 00	-1.13756D 00
	-8.47164D-01	-8.51087D-02	2.24283D 00	-7.21390D-01	-4.95140D-02	2.46003D 00
NODE 1	2.64721D 02	-3.21524D 02	-1.18140D 02			
	3.13153D 03	-8.73592D-01	2.98315D 02			
	3.10947D 03	-2.03231D 02	4.30501D 02			
	-2.13552D-01	-1.32329D 00	1.81659D 00	-7.53961D-01	-5.36272D-01	2.42082D 00
NODE 2	2.81845D 02	-3.21872D 02	-8.45587D 01			
	3.13459D 03	1.43295D 00	2.96776D 02			
	3.11273D 03	-2.00995D 02	4.29279D 02			

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 4 OF 11)

-8.47164D-01	-8.51087D-02	2.24283D 00	-7.21390D-01	-4.95140D-02	2.46003D 00

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 5 OF 11)

LT.SAMPLE.DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

TIME = 0.050000   NUMBER OF INTEGRATION INTERVALS = 200

MASS DISPLACEMENTS,VELOCITIES,AND ACCELERATIONS

	X XDOT U UDOT XACCEL	Y YDOT V VDOT YACCEL	Z ZDOT W WDOT ZACCEL	PHI PHIDOT P PDOT XACFIL	THETA THETADOT Q QDOT YACFIL	PSI PSIDOT R RDOT ZACFIL
MASS 17	9.82658D 01	-5.51659D 02	-1.09650D 02	-6.29956D-02	4.74938D-02	6.00626D-02
	3.13561D 03	-1.95471D 00	3.09650D 02	-1.00923D-01	2.19182D-01	5.31816D-02
	3.11161D 03	-2.18620D 02	4.45013D 02	-1.03448D-01	2.15403D-01	6.68146D-02
	-9.80839D 02	-2.50530D 02	5.69162D 02	4.47761D-01	4.58497D 00	1.19772D 00
	-2.25486D 00	8.82634D-03	-2.03297D-01	-1.45298D 00	-9.17273D-02	1.88957D-01
NODE 1	8.22150D 01	-5.51003D 02	-1.41812D 02			
	3.12873D 03	-6.54477D 00	3.12990D 02			
	3.10432D 03	-2.22969D 02	4.47742D 02			
	-2.65264D 00	1.44946D-03	-2.22948D-02	-1.90514D 00	-1.79261D-01	3.84171D-01
MASS 18	1.11241D 02	-1.32428D 02	-1.48176D 01	8.69036D-03	-3.81786D-02	1.21342D-04
	3.13098D 03	1.51657D 01	-1.09811D 01	-2.86731D-01	2.42899D-01	9.42868D-03
	3.12828D 03	1.36513D 01	-1.30605D 02	-2.86371D-01	2.42972D-01	7.31059D-03
	1.09036D 04	4.17784D 02	1.65221D 04	-9.44067D 00	1.83090D 02	2.39094D 00
	2.81652D 01	1.04469D 00	4.08242D 01	2.81838D 01	2.51583D 00	2.63641D 01
MASS 19	7.22352D 02	0.0	-1.21246D 01	0.0	-7.80386D-03	0.0
	3.03863D 03	0.0	1.48077D 02	0.0	-2.38105D 00	0.0
	3.03969D 03	0.0	1.24360D 02	0.0	-2.38105D 00	0.0
	-2.18524D 03	0.0	-9.44612D 03	0.0	-3.95043D 01	0.0
	-6.42837D 00	0.0	-5.72139D 00	-1.10172D 01	0.0	-6.89077D 00
MASS 20	6.99457D 02	0.0	-1.64051D 02	0.0	1.82746D-02	0.0
	3.13462D 03	0.0	2.48923D 02	0.0	7.00760D-02	0.0
	3.12955D 03	0.0	3.06162D 02	0.0	7.00760D-02	0.0
	-2.31845D 02	0.0	2.42072D 02	0.0	-5.21308D 00	0.0
	-5.45052D-01	0.0	5.89784D-02	-4.19059D-01	0.0	1.54281D-01
MASS 21	6.99436D 02	0.0	-1.63954D 02	0.0	2.01807D-02	0.0
	3.13504D 03	0.0	2.51219D 02	0.0	7.59870D-02	0.0
	3.12933D 03	0.0	3.14431D 02	0.0	7.59870D-02	0.0
	-1.91988D 02	0.0	9.88232D 01	0.0	-4.23777D 00	0.0
	-4.35480D-01	0.0	-3.60014D-01	-3.30037D-01	0.0	-2.72744D-01

NO MASS IMPULSE DATA REQUESTED

BEAM FORCES

STRAIN FORCES

I	J	M	N	FX	FY	FZ	MX	MYI	MYJ	MZI	MZJ
1	2	0	0	3.2204D 03	0.0	-8.0977D 02	0.0	-9.4846D 04	1.3052D 04	0.0	0.0
2	3	0	0	1.4479D 04	0.0	2.4521D 04	0.0	-2.9057D 04	3.9602D 06	0.0	0.0
3	4	0	0	3.7752D 04	0.0	-5.4781D 03	0.0	-4.2344D 06	3.4080D 06	0.0	0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 6 OF 11)

4	5	0	0	4.8613D 04	0.0	-5.7623D 04	0.0	-3.7026D 06	-7.8272D 06	0.0	0.0
5	6	0	0	-1.7876D 05	0.0	1.7035D 05	0.0	6.0791D 07	-3.6789D 07	0.0	0.0
6	7	0	0	-1.2388D 05	0.0	1.6789D 05	0.0	3.8496D 07	-2.5045D 07	0.0	0.0
7	8	0	0	-1.3734D 05	0.0	1.0991D 05	0.0	2.5150D 07	-7.4656D 06	0.0	0.0
8	9	0	0	-1.2596D 05	0.0	3.3555D 04	0.0	5.5220D 06	-3.1990D 04	0.0	0.0
9	10	0	0	-2.4314D 04	0.0	1.2374D 04	0.0	-1.8667D 05	2.8385D 06	0.0	0.0
5	11	0	1	-5.0323D 04	-1.0766D 05	-1.7100D 05	3.0071D 07	-1.0523D 07	-1.1320D 07	2.1650D 07	-7.8975D 06
11	12	1	0	9.0811D 03	-6.0953D 03	3.0186D 04	-3.0715D 06	5.0595D 06	1.6807D 05	3.4409D 06	-2.3856D 06
12	13	0	0	-4.5121D 03	-1.4623D 04	1.7306D 03	-1.5069D 06	-1.1718D 06	1.4900D 06	2.8232D 06	-1.3321D 05
13	14	0	0	2.3996D 03	-2.4318D 04	-1.1922D 04	-1.0093D 06	-1.7605D 06	-4.4925D 05	3.1703D 05	4.1901D 06
14	15	0	1	5.9501D 04	4.2940D 04	1.5548D 03	2.6171D 05	5.1821D 05	-2.2547D 05	-4.5155D 06	-3.5691D 06
12	16	1	1	3.7516D 03	-5.4960D 02	-8.1484D 03	5.0611D 04	-9.9520D 05	3.7504D 05	1.3341D 04	2.8486D 04
14	17	1	1	1.1199D 04	8.3251D 02	5.1068D 03	-2.0717D 04	2.4664D 05	1.4199D 05	-6.8623D 04	5.2726D 03
11	18	2	0	-1.9229D 04	2.0351D 03	-5.4773D 04	-2.2337D 03	-5.3310D 06	5.7595D 05	-2.0194D 05	1.4920D 04
11	18	3	0	-2.9907D 01	2.0351D 03	-5.4773D 04	-2.2337D 03	-5.3310D 06	5.7595D 05	-2.0194D 05	1.4920D 04
2	19	1	0	-3.5208D 03	0.0	-9.6641D 03	0.0	-7.2640D 05	1.2916D 05	0.0	0.0
6	12	0	0	1.7741D 04	5.6656D 03	-5.3383D 03	1.2634D 06	-1.5613D 06	0.0	-1.6571D 06	0.0
9	14	0	0	9.3714D 04	0.0	-4.1581D 03	7.0787D 05	-1.8226D 06	-9.3357D 05	0.0	0.0
12	0	0	0	-3.4298D 04	0.0	0.0	0.0	-4.7960D 05	4.7960D 05	5.0704D 05	-5.0704D 05
2	20	0	0	-7.7092D 02	0.0	9.0175D 01	0.0	9.8263D 02	8.1450D 02	0.0	0.0
2	21	0	0	-1.1271D 03	0.0	8.4212D 01	0.0	8.1578D 02	8.5485D 02	0.0	0.0
15	16	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	16	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0	0	0	0.0	0.0	0.0	0.0	-2.8606D 05	2.8606D 05	5.0542D 05	-5.0542D 05
15	0	2	0	-7.4156D 04	0.0	0.0	0.0	-2.8606D 05	2.8606D 05	5.0542D 05	-5.0542D 05

TOTAL FORCES (STRAIN+DAMPING)

I	J	M	N	FX	FY	FZ	MX	MYI	MYJ	MZI	MZJ
1	2	0	0	3.2023D 03	0.0	-8.2173D 02	0.0	-9.0349D 04	7.3468D 03	0.0	0.0
2	3	0	0	1.4023D 04	0.0	2.5080D 04	0.0	2.7071D 04	3.9937D 06	0.0	0.0
3	4	0	0	3.6859D 04	0.0	-5.3162D 03	0.0	-4.3550D 06	3.5045D 06	0.0	0.0
4	5	0	0	4.7638D 04	0.0	-5.8597D 04	0.0	-3.8168D 06	-7.9078D 06	0.0	0.0
5	6	0	0	-1.7861D 05	0.0	1.7177D 05	0.0	6.1010D 07	-3.6874D 07	0.0	0.0
6	7	0	0	-1.2353D 05	0.0	1.6815D 05	0.0	3.8531D 07	-2.5059D 07	0.0	0.0
7	8	0	0	-1.3706D 05	0.0	1.0990D 05	0.0	2.5199D 07	-7.5170D 06	0.0	0.0
8	9	0	0	-1.2589D 05	0.0	3.3667D 04	0.0	5.6137D 06	-1.0534D 05	0.0	0.0
9	10	0	0	-2.3878D 04	0.0	1.2675D 04	0.0	-1.1503D 05	2.8314D 06	0.0	0.0
5	11	0	1	-5.1516D 04	-1.0715D 05	-1.7360D 05	3.0523D 07	-1.0643D 07	-1.1531D 07	2.1668D 07	-7.9799D 06
11	12	1	0	8.5379D 03	-6.4369D 03	3.0817D 04	-3.0110D 06	5.2422D 06	9.4718D 04	3.5472D 06	-2.4328D 06
12	13	0	0	-4.7185D 03	-1.4612D 04	1.7867D 03	-1.5679D 06	-1.1445D 06	1.4730D 06	2.8275D 06	-1.3966D 05
13	14	0	0	2.1133D 03	-2.4449D 04	-1.1482D 04	-1.0341D 06	-1.7252D 06	-4.0298D 05	3.5713D 05	4.1744D 06
14	15	0	1	5.9498D 04	4.2977D 04	1.3996D 03	2.5312D 05	4.9538D 05	-2.3186D 05	-4.5243D 06	-3.5671D 06
12	16	1	1	4.0782D 03	-3.2687D 02	-7.1406D 03	5.5518D 04	-9.9059D 05	4.4712D 05	4.4515D 03	2.0426D 04
14	17	1	1	1.1547D 04	7.7257D 02	5.5299D 03	-2.0099D 04	2.5324D 05	1.6760D 05	-6.9226D 04	1.0438D 04
11	18	2	0	-2.4626D 05	1.8193D 03	-5.4299D 04	-2.4402D 03	-5.2900D 06	5.7359D 05	-1.8431D 05	1.4894D 04
11	18	3	0	-2.9907D 01	1.8193D 03	-5.4299D 04	-2.4402D 03	-5.2900D 06	5.7359D 05	-1.8431D 05	1.4894D 04
2	19	1	0	-3.6894D 04	0.0	-9.9288D 03	0.0	-7.4520D 05	1.3176[illegible] 05	0.0	0.0
6	12	0	0	1.8279D 04	5.7127D 03	-5.3578D 03	1.3232D 06	-1.5671D 06	0.0	-1.6709D 06	0.0
9	14	0	0	9.4547D 04	0.0	-4.1329D 03	7.1606D 05	-1.7802D 06	-9.5926D 05	0.0	0.0
12	0	0	0	-3.3977D 04	0.0	0.0	0.0	-3.5193D 05	3.5193D 05	4.3108D 05	-4.3108D 05
2	20	0	0	-9.3972D 02	0.0	5.2880D 02	0.0	5.3234D 03	5.2131D 03	0.0	0.0
2	21	0	0	-1.3586D 03	0.0	4.1932D 02	0.0	4.0772D 03	4.2378D 03	0.0	0.0
15	16	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	16	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0	0	0	0.0	0.0	0.0	0.0	-2.9991D 05	2.9991D 05	4.9331D 05	-4.9331D 05
15	0	2	0	-7.4156D 04	0.0	0.0	0.0	-2.9991D 05	2.9991D 05	4.9331D 05	-4.9331D 05

COMPONENTS OF TOTAL BEAM FORCES ACTING ON MASSES I AND J

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 7 OF 11)

LOADS ARE THOSE ACTING ON THE MASS, IN MASS AXES, +FWD,RT,DN
FOR EACH BEAM, FIRST LINE IS MASS I, SECOND LINE IS MASS J

I	J	M	N	FX	FY	FZ	MX	MY	MZ
1	2	0	0	-3.2126D 03	0.0	-7.8047D 02	0.0	-9.0349D 04	0.0
				3.2126D 03	0.0	7.8044D 02	0.0	7.3468D 03	0.0
2	3	0	0	-1.2434D 04	0.0	2.5904D 04	0.0	2.7071D 04	0.0
				1.2424D 04	0.0	-2.5909D 04	0.0	3.9937D 06	0.0
3	4	0	0	-3.6942D 04	0.0	-4.7073D 03	0.0	-4.3550D 06	0.0
				3.6945D 04	0.0	4.6809D 03	0.0	3.5045D 06	0.0
4	5	0	0	-4.9317D 04	0.0	-5.7191D 04	0.0	-3.8168D 06	0.0
				4.9300D 04	0.0	5.7206D 04	0.0	-7.9078D 06	0.0
5	6	0	0	1.6362D 05	0.0	1.8610D 05	0.0	6.1010D 07	0.0
				-1.6251D 05	0.0	-1.8707D 05	0.0	-3.6874D 07	0.0
6	7	0	0	1.3294D 05	0.0	1.6081D 05	0.0	3.8531D 07	0.0
				-1.3264D 05	0.0	-1.6106D 05	0.0	-2.5059D 07	0.0
7	8	0	0	1.2470D 05	0.0	1.2375D 05	0.0	2.5199D 07	0.0
				-1.2441D 05	0.0	-1.2404D 05	0.0	-7.5170D 06	0.0
8	9	0	0	1.1585D 05	0.0	5.9675D 04	0.0	5.6137D 06	0.0
				-1.1580D 05	0.0	-5.9769D 04	0.0	-1.0534D 05	0.0
9	10	0	0	2.0904D 04	0.0	1.7141D 04	0.0	-1.1503D 05	0.0
				-2.0910D 04	0.0	-1.7134D 04	0.0	2.8314D 06	0.0
5	11	0	1	-1.0991D 05	-7.9150D 03	-1.7925D 05	2.1963D 07	-2.6509D 07	-1.8147D 07
				1.1345D 05	9.1581D 03	1.7697D 05	-5.4247D 05	2.8656D 07	4.7894D 06
11	12	1	0	-1.0846D 04	-7.2746D 03	2.9891D 04	-3.1465D 06	4.5160D 06	-3.4309D 06
				1.1041D 04	7.2994D 03	-2.9814D 04	-1.5609D 06	-2.8357D 06	2.1251D 06
12	13	0	0	-1.0411D 04	1.1198D 04	2.2769D 03	1.8929D 06	1.0193D 06	-2.6723D 06
				1.0415D 04	-1.1219D 04	-2.1463D 03	-2.0613D 06	-6.3144D 05	-5.0260D 03
13	14	0	0	-2.0702D 04	1.3132D 04	-1.1534D 04	2.0292D 06	-6.6070D 04	-2.2643D 05
				2.0605D 04	-1.3072D 04	1.1774D 04	7.2448D 04	-6.5108D 05	-4.2694D 06
14	15	0	1	3.7826D 03	-7.3206D 04	-3.9466D 03	-7.8554D 05	-2.8357D 05	4.4812D 06
				-3.7376D 03	7.3176D 04	4.5021D 03	6.0526D 05	-2.8216D 04	9.8394D 05
12	16	1	1	4.0505D 03	-3.1135D 02	-7.1570D 03	4.1307D 05	1.2946D 06	1.8662D 05
				-4.3214D 03	-5.1590D 01	7.0035D 03	-5.3018D 04	-1.8392D 05	-4.3435D 04
14	17	1	1	1.1542D 04	7.9513D 02	5.5375D 03	1.3849D 05	-2.7184D 05	-2.5773D 05
				-1.1370D 04	3.6937D 02	-5.9239D 03	1.7138D 03	1.1959D 05	1.1744D 04
11	18	2	0	-4.8129D 04	-1.6132D 03	-2.4754D 05	3.4899D 06	-2.6918D 07	-5.0398D 05
				5.7370D 04	1.9422D 03	2.4557D 05	-1.4902D 04	5.7359D 05	2.3482D 03
11	18	3	0	-5.4282D 04	-1.8154D 03	-1.3882D 03	2.1811D 05	-5.8758D 06	-5.6847D 05
				5.4295D 04	1.8228D 03	-6.4904D 02	-1.4902D 04	5.7359D 05	2.3482D 03
2	19	1	0	-9.2882D 03	0.0	-3.7061D 04	0.0	-6.2324D 05	0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 8 OF 11)

				1.0312D 04	0.0	3.6789D 04	0.0	1.3176D 05	0.0
6	12	0	0	1.2151D 04	-1.4974D 04	-4.8560D 03	1.9138D 06	-6.1939D 05	1.7182D 06
				-1.2046D 04	1.5015D 04	4.9907D 03	-4.8797D 05	1.2296D 06	-3.0638D 04
9	14	0	0	4.5076D 04	-8.3152D 04	-3.1947D 03	1.9062D 06	2.1798D 05	3.0019D 04
				-4.4676D 04	8.3409D 04	1.7933D 03	5.0708D 05	1.0839D 06	-2.9935D 04
12	0	0	0	-2.2266D 01	-3.3976D 04	2.2143D 02	-3.5194D 05	-2.5788D 03	-4.3107D 05
				THERE IS NO MASS AT J END OF THIS BEAM					
2	20	0	0	5.2522D 02	0.0	9.4172D 02	0.0	-5.3234D 03	0.0
				-5.2678D 02	0.0	-9.4085D 02	0.0	-5.2131D 03	0.0
2	21	0	0	0.0	0.0	0.0	0.0	0.0	0.0
				-4.1530D 02	0.0	-1.3598D 03	0.0	-4.2378D 03	0.0
15	16	0	0	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.0	0.0	0.0	0.0
15	16	2	2	0.0	0.0	0.0	0.0	0.0	0.0
				0.0	0.0	0.0	0.0	0.0	0.0
15	0	0	0	0.0	0.0	0.0	-2.9991D 05	-7.3245D 03	-4.9326D 05
				THERE IS NO MASS AT J END OF THIS BEAM					
15	0	2	0	-3.4672D 02	-7.4144D 04	1.3118D 03	-2.9991D 05	-7.3245D 03	-4.9326D 05
				THERE IS NO MASS AT J END OF THIS BEAM					

BEAM RELATIVE DEFLECTIONS AND ROTATIONS AND BEAM EULER ANGLES (INCHES AND DEGREES)

BEAM				DEFLECTIONS (J-I)			ROTATIONS (J-I)			ROTATIONS (J+I)		V	EULER ANGLES	
												B		
I	J	M	N	X	Y	Z	PHI	THETA	PSI	THETA	PSI	M	THETA	PSI
1	2	0	0	1.0165D-03	0.0	-5.5700D-04	0.0	5.0358D-04	0.0	-2.8429D-01	0.0	0	-1.9	180.0
2	3	0	0	6.4476D-03	0.0	-2.2363D-02	0.0	2.3795D-02	0.0	-2.5999D-01	0.0	0	-4.7	180.0
3	4	0	0	1.6781D-02	0.0	-5.9455D-02	0.0	4.1006D-02	0.0	-1.9519D-01	0.0	0	-2.1	180.0
4	5	0	0	1.6486D-02	0.0	2.0709D-03	0.0	-1.7385D-02	0.0	-1.7157D-01	0.0	0	-2.7	180.0
5	6	0	0	-4.2575D-02	0.0	4.4932D-01	0.0	-3.3865D-01	0.0	-5.2761D-01	0.0	0	3.7	180.0
6	7	0	0	-1.7412D-02	0.0	8.0283D-02	0.0	-1.0724D-01	0.0	-9.7350D-01	0.0	0	-4.7	180.0
7	8	0	0	-4.6039D-02	0.0	2.1871D-01	0.0	-1.3188D-01	0.0	-1.2126D 00	0.0	0	4.5	180.0
8	9	0	0	-5.5706D-02	0.0	8.8372D-02	0.0	-4.6500D-02	0.0	-1.3910D 00	0.0	0	10.6	180.0
9	10	0	0	-2.0843D-02	0.0	-2.7262D-02	0.0	2.0637D-02	0.0	-1.4169D 00	0.0	0	9.7	180.0
5	11	0	1	-1.2023D-02	-1.2215D-01	-1.6645D-01	1.2066D 00	-1.8286D-02	-9.4856D-02	5.0365D-02	-7.6441D-02	0	-5.8	-68.7
11	12	1	0	2.4887D-03	-4.5405D-02	4.3635D-01	-3.0851D-01	-2.1292D-01	-2.8345D-02	1.4841D 00	1.9016D-01	0	5.8	-117.1
12	13	0	0	-1.4743D-03	-5.6197D-02	-4.5999D-01	-4.1797D-01	2.9845D-01	-2.6862D-02	1.6095D 00	1.2497D-01	0	5.5	-119.9
13	14	0	0	1.0928D-03	9.6950D-02	-8.7936D-01	-5.8765D-01	3.4814D-01	9.7928D-02	2.2490D 00	1.6861D-01	0	8.0	-123.9
14	15	0	1	5.6013D-02	4.0334D-01	6.2125D-01	2.7516D-01	-3.3426D-01	6.3806D-02	2.2846D 00	3.8560D-01	0	6.0	-122.9
12	16	1	1	3.3986D-03	1.6671D-03	-2.9704D-01	2.4985D-01	3.8862D-01	3.1455D-02	-9.4644D-01	9.8983D-02	0	0.6	0.0
14	17	1	1	1.0145D-02	1.3100D-01	4.4110D-02	-1.0227D-01	-2.9678D-02	1.5342D-01	-3.9651D-01	5.8823D-01	0	0.8	0.3
11	18	2	0	-7.4061D 00	7.5502D-02	-2.1725D 00	-6.9119D-03	2.1480D 00	7.5196D-02	4.2266D 00	9.1959D-01	1	1.5	-179.5
11	18	3	0	-7.4061D 00	7.5502D-02	-2.1725D 00	-6.9119D-03	2.1480D 00	7.5196D-02	4.2266D 00	9.1959D-01	1	1.5	-179.5
2	19	1	0	-1.2587D 00	0.0	-1.0678D 00	0.0	1.5865D 00	0.0	1.3027D 00	0.0	1	-0.1	180.0
6	12	0	0	1.2749D-02	2.2501D-01	-2.2261D 00	1.1607D 00	-5.8914D-02	9.9165D-03	2.6086D-01	2.7485D-02	0	-0.9	-68.3
9	14	0	0	1.5262D-01	1.5855D 00	-9.9282D 00	1.4739D 00	8.4410D-01	2.2855D-01	1.5286D 00	2.3372D-01	0	0.3	-61.6
12	0	0	0	-4.5802D-02	-3.5662D-01	-3.5418D 00	0.0	7.4676D-01	-7.5189D-02	0.0	0.0	0	0.0	90.0
2	20	0	0	-7.5377D-02	0.0	7.5738D-02	0.0	-9.4619D-02	0.0	1.8917D-01	0.0	1	0.9	0.0
2	21	0	0	-1.7220D-01	0.0	5.3248D-02	0.0	1.4585D-02	0.0	2.9837D-01	0.0	1	1.0	0.0
15	16	0	0	7.4813D-02	-7.9765D-01	1.8515D 00	-3.2985D-01	2.5063D-01	-1.3958D-01	-1.5407D 00	2.0390D-01	0	-9.2	46.8

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 9 OF 11)

15	16	2	2	7.4813D-02	-7.9765D-01	1.8515D 00	-3.2985D-01	2.5063D-01	-1.3958D-01	-1.5407D 00	2.0390D-01	0	-9.2	46.8
15	0	0	0	-8.4888D-01	-6.9222D 00	-2.6120D 01	0.0	2.0219D 00	-5.3585D-01	0.0	0.0	0	0.0	90.0
15	0	2	0	-8.4888D-01	-6.9222D 00	-2.6120D 01	0.0	2.0219D 00	-5.3585D-01	0.0	0.0	0	0.0	90.0

EXTERNAL SPRINGS

						GROUND CONTACT POINT LOADS IN GROUND OR SLOPE AXES			GROUND CONTACT POINT LOADS IN MASS AXES		
MASS I	SPRING K	M	SPRING COMPRESSION	GROUND DEFLECTION	SPRING COMPRESSION LOAD	X(+ AFT OR DOWN SLOPE)	Y(+ LEFT)	Z(+ UP OR NOR-MAL TO SLOPE)	X (+ FORWARD)	Y (+ RIGHT)	Z (+ DOWN)
1	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	3	0	4.82097D 00	0.0	1.70589D 05	5.11364D 04	3.16689D 02	1.70458D 05	-5.76055D 04	-1.77376D 03	-1.68373D 05
19	3	0	4.32507D 00	0.0	3.84812D 04	1.15440D 04	0.0	3.84800D 04	-1.18439D 04	0.0	-3.83888D 04

DRI RESULTS: MASS NO. AND DRI VALUE

MASS	DRI
21	1.12790D 00

VEHICLE C.G. TRANSLATIONAL VELOCITIES, GROUND AXES, BASED ON SYSTEM LINEAR MOMENTUM

XDOT (+FWD)	YDOT (+RIGHT)	ZDOT (+DOWN)
3.12984D 03	0.0	2.67220D 02

ENERGY DISTRIBUTION

TOTAL ENERGY	KINETIC ENERGY	POTENTIAL ENERGY+	STRAIN ENERGY	DAMPING ENERGY	CRUSHING ENERGY	FRICTION ENERGY
2.42972D 09	2.38520D 09	2.50557D 07	1.68450D 06	2.27838D 06	9.07538D 05	1.45927D 07
PERCENT OF TOTAL ENERGY	98.168	1.031	0.069	0.094	0.037	0.601

INTERNAL BEAM

EXTERNAL SPRING

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 10 OF 11)

MASS	KINETIC ENERGY	PCT	POTENTIAL ENERGY+	PCT
1	2.020D 07	0.8	2.352D 05	0.9
2	1.156D 08	4.8	1.316D 06	5.3
3	1.956D 08	8.2	2.036D 06	8.1
4	1.674D 08	7.0	1.718D 06	6.9
5	2.782D 08	11.7	2.650D 06	10.6
6	1.010D 08	4.2	1.022D 06	4.1
7	1.176D 08	4.9	1.130D 06	4.5
8	1.271D 08	5.3	1.317D 06	5.3
9	7.280D 07	3.1	9.281D 05	3.7
10	7.859D 07	3.3	7.652D 05	3.1
11	2.470D 08	10.4	2.485D 06	9.9
12	2.577D 08	10.8	3.179D 06	12.7
13	1.354D 08	5.7	1.912D 06	7.6
14	9.608D 07	4.0	1.487D 06	5.9
15	3.923D 07	1.6	5.909D 05	2.4
16	1.387D 08	5.8	9.234D 05	3.7
17	1.325D 08	5.6	1.136D 06	4.5
18	4.881D 07	2.0	5.696D 04	0.2
19	2.854D 06	0.1	2.886D 03	0.0
20	1.281D 07	0.5	1.641D 05	0.7
21	0.0	0.0	0.0	0.0

IJ	I	J	M	N	STRAIN ENERGY	PCT	DAMPING ENERGY	PCT
1	1	2	0	0	1.983D 00	0.0	2.428D-01	0.0
2	2	3	0	0	5.985D 02	0.0	3.324D 01	0.0
3	3	4	0	0	1.709D 03	0.1	8.885D 01	0.0
4	4	5	0	0	1.537D 03	0.1	8.172D 01	0.0
5	5	6	0	0	1.510D 05	9.0	6.403D 02	0.0
6	6	7	0	0	3.128D 04	1.9	8.482D 01	0.0
7	7	8	0	0	2.380D 04	1.4	1.927D 02	0.0
8	8	9	0	0	5.018D 03	0.3	1.205D 02	0.0
9	9	10	0	0	6.027D 02	0.0	6.036D 01	0.0
10	5	11	0	1	6.928D 05	41.1	1.587D 04	0.7
11	11	12	1	0	3.078D 04	1.8	5.244D 03	0.2
12	12	13	0	0	1.892D 04	1.1	1.883D 03	0.1
13	13	14	0	0	2.294D 04	1.4	7.442D 02	0.0
14	14	15	0	1	2.022D 04	1.2	5.153D 01	0.0
15	12	16	1	1	5.240D 03	0.3	7.743D 02	0.0
16	14	17	1	1	4.283D 02	0.0	6.712D 01	0.0
17	11	18	2	0	3.469D 05	20.6	2.227D 06	97.7
18	11	18	3	0	1.809D 05	10.7	-4.099D 03	-0.2
19	2	19	1	0	1.125D 04	0.7	2.744D 04	1.2
20	6	12	0	0	3.899D 04	2.3	9.528D 02	0.0
21	9	14	0	0	6.005D 04	3.6	1.778D 02	0.0
22	12	0	0	0	4.250D 03	0.3	9.783D 02	0.0
23	2	20	0	0	3.182D 01	0.0	2.249D 01	0.0
24	2	21	0	0	0.0	0.0	0.0	0.0
25	15	16	0	0	0.0	0.0	0.0	0.0
26	15	16	2	2	0.0	0.0	0.0	0.0
27	15	0	0	0	7.411D 03	0.4	1.857D 01	0.0
28	15	0	2	0	2.776D 04	1.6	1.857D 01	0.0

I	K	M	CRUSHING ENERGY	PCT	FRICTION ENERGY	PCT
1	3	0	0.0	0.0	0.0	0.0
2	3	0	0.0	0.0	0.0	0.0
3	3	0	0.0	0.0	0.0	0.0
4	3	0	0.0	0.0	0.0	0.0
5	3	0	0.0	0.0	0.0	0.0
6	3	0	0.0	0.0	0.0	0.0
7	3	0	0.0	0.0	0.0	0.0
8	3	0	0.0	0.0	0.0	0.0
9	3	0	0.0	0.0	0.0	0.0
10	3	0	0.0	0.0	0.0	0.0
11	3	0	0.0	0.0	0.0	0.0
12	3	0	0.0	0.0	0.0	0.0
13	3	0	0.0	0.0	0.0	0.0
14	3	0	0.0	0.0	0.0	0.0
15	3	0	0.0	0.0	0.0	0.0
16	3	0	0.0	0.0	0.0	0.0
17	3	0	0.0	0.0	0.0	0.0
18	3	0	8.259D 05	91.0	1.416D 07	97.0
19	3	0	8.169D 04	9.0	4.325D 05	3.0

DEVIATION OF TOTAL ENERGY OF EACH MASS FROM 100 PERCENT

MASS	DEVIATION(PERCENT)
1	0.001197
2	0.001206
3	0.001039
4	0.000793
5	0.000535
6	0.000738
7	0.000840
8	0.001039
9	0.001200
10	0.001944
11	0.000318
12	0.000793
13	0.001573
14	0.001386
15	0.001543
16	0.000323
17	0.001363
18	-0.018055
19	0.001381
20	0.000312
21	0.0

FIGURE 2-23. KRASH85 TIME HISTORY OUTPUT (SHEET 11 OF 11)

the angular velocity of mass I, using the same sign convention as for the Euler angles. PDOT, QDOT and RDOT are the body axes components of the angular accelerations of mass I. None of these orientation quantities is output for the node points, since these are the same as for the mass to which a given node point is attached.

XIMPULSE, YIMPULSE, ZIMPULSE are the accumulated area under the filtered acceleration response curve (G-SEC). Normally the user should plot these data to evaluate its meaning.

2.3.3.2.2 Internal Beam Data. - The STRAIN FORCES and TOTAL FORCES (STRAIN + DAMPING) are both output in the same format. FX, FY and FZ are the forces in beam axes acting upon the beam at the j end of the beam. Equal and opposite forces act upon the beam at the i end. MX is the torsion acting at the j end; again an equal and opposite torsion acts at the i end. MYI and MYJ are the bending moments at each end of the beam, acting about the beam y axis. MZI and MZJ are the moments acting about the beam z axis. In general, the moments acting at the i and j ends of the beam are not equal. The i and j ends of the beam are at masses i and j, unless the beam connects to a node point. In this case the i end of the beam is actually located at node point I, M, and the j end at node point J, N. M or N equal to zero means there is no node point; direct mass connection is used. The sign convention for these loads is shown in figure 2-18.

The total beam forces can also be output in a format which shows, for each beam, the loads acting at the I and J masses. This output is titled COMPONENTS OF TOTAL BEAM FORCES ACTING ON MASSES I AND J. For each beam the first line of output shows the forces on mass I, the second line shows mass J. These loads are positive forward, right and down, in mass axes, with moments using right-hand-rule about those axes. The loads are those acting on the masses, not the loads acting on the beams.

The beam X, Y and Z deflection data are presented in relative form, i.e., the values represent deflections at the j end minus those at the i end. The beam rotation data are given in both (J-I) and (J+I) terms. This is done

because the strain forces are calculated using both sum and difference terms. Note that these angles are all in degrees, rather than radians. If the actual rotations at the j and i beam ends are desired, they can be calculated from the output data as

$$\mathrm{THETA(J)} = \frac{\mathrm{THETA(J+I)} + \mathrm{THETA(J-I)}}{2}$$

$$\mathrm{THETA(I)} = \frac{\mathrm{THETA(J+I)} - \mathrm{THETA(J-I)}}{2}$$

Similar equations apply to PSI.

The beam lateral deflections Y and Z which are printed out are not simply the (J-I) values. The θ and ψ rotations of mass I cause Z and Y deflections at end J, which in themselves cause no beam loads. These deflection components are removed from the output deflections. The output deflections are the following

$$Y_{output} = (Yj - Yi) - \ell * \psi i$$

$$Z_{output} = (Zj - Zi) + \ell * \theta i$$

The Euler angles defining the current orientation of the beam axes are also output in degrees. The column of integers titled VBM define which beams, if any, are treated as vertical beams. For vertical beams, VBM=1; for normal beams, VBM=0. For normal beams, the following procedure is used to determine the current beam axes orientation.

- Start with the ground fixed axis system, with X positive forward, Y positive right and Z positive downward.
- Rotate PSI degrees about the Z axis, using right-hand-rule for positive rotations.
- Rotate THETA degrees about the new rotated Y axis, using right-hand-rule for positive rotations.

For vertical beams (VBM=1), the same procedure is used, but the initial orientation of the X, Y, Z axis is different. In this case, the initial orientation is X positive up, Y positive right and Z positive forward.

For either axis orientation system, there is actually a final rotation of PHI about the X axis. PHI is not shown primarily due to output format line width limitations. However, PHI is normally rather small and will not affect the user's interpretation of the orientation of the beam axes.

2.3.3.2.3 <u>External Spring Data</u>. - For each external spring, the spring compression in inches and compression load in pounds is output. These are along the spring axis, which is oriented parallel to one of the mass axes. The ground deflection is also shown; this deflection will be zero if the ground flexibility is input as zero. The ground contact point loads are given in two coordinate systems, ground axes and mass axes. If the spring in question is on a slope, then slope axes are used instead of ground axes. The output titles for these quantities are self-explanatory.

2.3.3.2.4 <u>DRI and c.g. Velocity Data</u>. - For each beam element which has been defined as a Dynamic Response Index (DRI) type element, the J mass and DRI number are shown. Volume I, Section 1.3.12 explains the theory and usage of DRI elements.

The overall vehicle c.g. velocities, in ground axes, are always output. These velocities are calculated such that the total vehicle weight, with these velocity components, would yield the same linear momentum as that existing in the total system of NM masses. Section 1.3.9 of Volume I explains how these values are derived. This output, particularly the time-history plot of same, is a very useful indicator of the overall vertical motion of the system. Since the system kinetic energy is a scalar quantity, there is no way to separate the kinetic energy due to horizontal motion from that due to vertical motion. Therefore, for analyses in which the horizontal velocity is much larger than the vertical, system kinetic energy is not very useful in determining when the vertical impact velocity has been absorbed. The vertical component of the overal c.g. velocity can be used for this purpose.

2.3.3.2.5 Energy Distribution Data. - The first output in this section of data shows the current total system energy, kinetic energy, potential energy, strain energy, damping energy, crushing energy and friction energy. The next section of output shows the contributions of the individual masses, internal beams and external springs to these system totals. The system kinetic energy should reduce to zero at the conclusion of the analytical run. From a practical standpoint, however, one can expect individual elements to oscillate slightly after the vehicle comes to rest, leaving some residual kinetic energy in the system long after the responses of interest have occurred. In general, it is anticipated that if the analysis shows a 75 percent reduction in kinetic energy, the most significant events will have been adequately described.

If the vehicle is impacting on a flat surface (no slope) and a substantial portion of the initial kinetic energy is due to forward velocity (parallel to the ground), then a much larger percentage of the initial kinetic energy may remain after the significant damage phase of the crash. The remaining energy is accounted for by the vehicle sliding along the ground with a substantial forward velocity. In this case, the vehicle cg translational velocities, printed earlier, provide a better indication of whether the major response phase has been adequately covered. In general, the ZDOT or vertical vehicle translational velocity should be reduced to zero, indicating that the vehicle has ceased its downward motion. This situation can also be seen when the system potential energy reaches a minimum.

The potential energies include the effects of user-defined input time histories of either loads or accelerations, applied to specified masses. That is the significance of the (+) at the end of the POTENTIAL ENERGY headings. Earlier versions of KRASH did not include the effects on the energy balance of the loads or acceleration input. These versions do not have the (+) in the potential energy heading.

The individual internal beam strain energies provide the user with valuable insight into the temporal and spatial flow of energy in the vehicle.

Generally speaking, the strain energy concentrates initially near the point of impact, and as the strain energy grows it also becomes diffused throughout the vehicle. After the peak responses in the system occur, the overall system strain energy will decrease from its peak value as the internal beam elements unload.

Certain individual nonlinear beam elements may indicate negative strain energy. This circumstance may occur when large deflection loading and unloading occurs in the coupled bending degrees of freedom ($z-\theta$ or $y-\psi$), with nonlinear KR curves applied to these directions. This phenomenon is discussed in Section 1.3.16 of Volume I, and is due to the approximate nature of the nonlinear element analytical model. In practice, these negative strain energies are of such small magnitude relative to the overall system strain energy (usually less than 1 percent) that they do not invalidate the overall analysis. Furthermore, these negative energies tend to occur toward the end of the analysis, during the unloading phase, after the primary responses and damage of interest have been determined. The plastic hinge option should be used in lieu of KR tables in the coupled bending directions; negative strain energy will not occur with the plastic hinge option. It should also be noted that negative strain energy does not occur for linear beam elements, or for those that are nonlinear only in the uncoupled degrees of freedom (axial and torsion).

The damping energy of the internal beams is usually small in relation to the strain energy, typically being less than 20 percent of the strain energy, until late in the run when the strain energy has decreased substantially from its peak value. Note that damping energy always increases with time, since it is a dissipative energy that is not stored and released as with strain energy.

Crushing and friction energies result from the deformation of the external springs and flexible ground for the former, and from sliding friction along the ground for the latter. The friction energy is also dissipative

and hence monotonically increasing, whereas the crushing energy peaks and decreases similar to the strain energy. In general, a rather large percentage of the total system energy may be represented by the crushing energy. This situation is only natural since the external springs represent the structure in immediate contact with the ground that undergoes substantial deformation. In a typical vehicle crash analysis, the system crushing energy may be larger than the internal beam strain energy. However, they both represent actual airplane structure, the only distinction being location on the vehicle.

The final energy information printed is a summary of the deviation of the total energy of each mass in the system from 100 percent. Ideally these variations should all be zero, but in actual practice errors associated with the numerical integration process result in deviations from the ideal. This information can be helpful for pinpointing areas of the mathematical model that may be causing numerical accuracy problems, and alerting the program user to the possible need for a finer integration time step.

In typical applications, a few individual mass total energies may deviate 2 to 5 percent from the 100 percent ideal, while the total energy of the entire system remains within 0.5 percent or less. This accuracy is generally considered acceptable for the numerical integration process. However, the program user is free to adjust the integration time step to suit his own personal criterion for the accuracy of the individual mass integrations.

2.2.3.2.6 <u>Internal Beam Stress Data.</u> - The stress data output are shown in figure 2-24, which is taken from the t = 0 output of the sample case. (Stress data output was not selected for the sample case, so none was output at t = 0.5 used for figure 2-23. At time zero, all output is printed regardless of what the user requests).

This output consists of ratios of current stress to failure level stress (corresponding to initial yielding), for four locations on each beam, using two failure theories. These theories are the maximum shear stress theory and the theory of constant energy of distortion. Section 1.3.17 of Volume I presents the method of calculating these ratios. Also shown in the output are the

ratios of current compressive/tensile stress to the corresponding yield stress, and the ratio of current axial compressive load (when it is compressive) to the critical buckling load.

The stress data can be used as a guide for estimating the time at which the element begins to yield. When such a state is reached, a stiffness reduction factor (KR) may be developed for the affected member which then can be used to approximate the nonlinear response characteristics of that member. The user is cautioned to exercise extreme care in the interpretation of data presented in the summary since they do not include the effect of stress concentrations, geometric shape factors, and detail attachment practices at joints. In addition, limitations of the program require that gross regions of the vehicle structure be modeled using relatively simple structural elements. Thus, the more gross the structural region the less accurate the stress values. Also monitoring the response of a structural element which may exhibit a buckling mode of failure will require special consideration. In this case the critical buckling load becomes significant and a stiffness reduction factor should be developed which will approximate the buckling characteristics of the element.

Furthermore, the user should realize that once an element has yielded or buckled, the failure theories followed become invalid and, consequently, the most meaningful use of the stress data is to identify which element may fail and at what point in time such failures are apt to occur.

2.3.3.2.7 Initial Mass Acceleration Error Output. - Figure 2-24 shows this output for the sample case. This information is only output at time zero, and has significance only if balanced initial conditions are used (KRASHIC and MSCTRAN are used to calculate balanced internal beam loads). For each mass in the system, the difference between the actual time zero acceleration calculated in KRASH85 and the theoretically correct value, based on airplane rigid body accelerations at time zero, is printed. A summary at the bottom shows the largest value and corresponding mass number for each of the six accelerations.

AD-A161 801 KRASH 85 USER'S GUIDE - INPUT/OUTPUT FORMAT(U) 3/3
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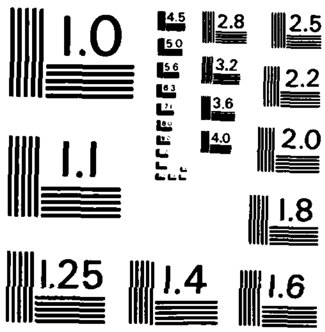

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

25	15	16	0	0	0.0	0.0	0.0	0.0
26	15	16	2	2	0.0	0.0	0.0	0.0
27	15	0	0	0	7.362D 03	2.1	1.118D-15	0.0
28	15	0	2	0	2.920D 04	8.2	1.118D-15	0.0

DEVIATION OF TOTAL ENERGY OF EACH MASS FROM 100 PERCENT

MASS	DEVIATION(PERCENT)
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
11	0.0
12	0.0
13	0.0
14	0.0
15	0.0
16	0.0
17	0.0
18	0.0
19	0.0
20	0.0
21	0.0

ELEMENT STRESSES

					RATIO OF CURRENT STRESS / FAILURE STRESS								RATIO OF CURRENT		
	BEAM				MAXIMUM SHEAR STRESS THEORY				THEORY OF CONSTANT ENERGY OF DISTORTION				AXIAL/FAILURE		BUCK. /
IJ	I	J	M	N	TOP	BOTTOM	LEFT	RIGHT	TOP	BOTTOM	LEFT	RIGHT	COMPR. STRESS	TENSILE STRESS	CR.BUCK. LOAD
1	1	2	0	0	6.636D-03	6.636D-03	3.980D-03	3.980D-03	6.446D-03	6.636D-03	3.446D-03	3.446D-03	1.849D-07		2.810D-10
2	2	3	0	0	7.081D-02	7.173D-02	2.654D-02	2.654D-02	6.878D-02	7.173D-02	2.298D-02	2.298D-02	4.625D-04		1.714D-06
3	3	4	0	0	1.092D-01	1.095D-01	5.858D-02	5.858D-02	1.060D-01	1.095D-01	5.073D-02	5.073D-02	1.873D-04		6.916D-07
4	4	5	0	0	1.462D-01	1.470D-01	4.779D-02	4.779D-02	1.420D-01	1.470D-01	4.139D-02	4.139D-02	3.898D-04		3.411D-06
5	5	6	0	0	2.696D-01	3.181D-01	4.587D-02	4.587D-02	2.619D-01	3.181D-01	4.153D-02	4.153D-02	2.426D-02		1.047D-04
6	6	7	0	0	2.432D-01	2.952D-01	6.616D-02	6.616D-02	2.362D-01	2.952D-01	5.875D-02	5.875D-02	2.600D-02		2.875D-05
7	7	8	0	0	2.241D-01	2.921D-01	5.568D-02	5.568D-02	2.177D-01	2.921D-01	5.113D-02	5.113D-02	3.401D-02		1.174D-04
8	8	9	0	0	1.466D-01	2.356D-01	4.960D-02	4.960D-02	1.424D-01	2.356D-01	4.839D-02	4.839D-02	4.454D-02		2.269D-04
9	9	10	0	0	7.563D-02	8.609D-02	8.166D-02	8.166D-02	7.347D-02	8.609D-02	7.077D-02	7.077D-02	5.228D-03		5.442D-05
10	5	11	0	1	1.052D-01	1.209D-01	9.239D-02	9.110D-02	8.979D-02	1.068D-01	8.145D-02	8.007D-02		4.754D-02	
11	11	12	1	0	5.357D-02	8.125D-02	6.156D-02	5.835D-02	4.802D-02	7.633D-02	5.797D-02	5.525D-02		5.056D-02	
12	12	13	0	0	1.700D-02	5.118D-02	4.083D-02	3.944D-02	1.528D-02	4.918D-02	3.594D-02	3.444D-02		1.981D-02	
13	13	14	0	0	2.526D-02	3.831D-02	3.459D-02	2.408D-02	2.344D-02	3.650D-02	3.330D-02	2.296D-02		2.700D-02	
14	14	15	0	1	2.141D-01	1.992D-01	1.106D-01	8.115D-02	1.881D-01	1.719D-01	1.073D-01	7.860D-02		9.236D-02	
15	12	16	1	1	1.446D-02	1.436D-02	4.276D-02	4.275D-02	1.353D-02	1.620D-02	3.468D-02	4.179D-02		4.490D-05	
16	14	17	1	1	1.361D-02	1.363D-02	4.083D-02	4.084D-02	1.274D-02	1.538D-02	3.312D-02	3.992D-02	1.520D-05		6.626D-07
17	11	18	2	0	1.997D 00	1.997D 00	1.997D 00	1.997D 00	1.997D 00	1.997D 00	1.997D 00	1.997D 00		1.997D 00	
18	11	18	3	0	5.182D-01	5.182D-01	5.179D-01	5.180D-01	5.180D-01	5.181D-01	5.178D-01	5.179D-01		5.176D-01	

FIGURE 2-24. KRASH85 INTERNAL BEAM STRESS DATA AND INITIAL MASS ACCELERATION ERROR OUTPUT (SHEET 1 OF 2)

19	2	19	1	0	3.096D-01	3.094D-01	3.097D-01	3.097D-01	3.096D-01	3.094D-01	3.096D-01	3.096D-01		?.095D-01	
20	6	12	0	0	4.075D-02	1.370D-02	1.800D-02	2.139D-02	4.036D-02	1.213D-02	1.700D-02	2.055D-02	1.569D-02		4.704D-03
21	9	14	0	0	1.183D-02	6.865D-02	4.133D-02	4.133D-02	1.150D-02	6.669D-02	3.989D-02	3.989D-02		3.909D-02	
22	12	0	0	0	5.892D-02	3.065D-02	4.580D-02	4.378D-02	5.892D-02	3.065D-02	4.580D-02	4.378D-02	4.479D-02		2.319D-02
23	2	20	0	0	1.347D-01	1.462D-01	1.405D-01	1.405D-01	2.861D-01	3.106D-01	2.985D-01	2.985D-01	2.984D-01		9.754D-03
24	2	21	0	0	2.623D-07	2.818D-07	2.729D-07	2.729D-07	5.573D-07	5.988D-07	5.795D-07	5.795D-07	5.781D-07		1.227D-08
25	15	16	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
26	15	16	2	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
27	15	0	0	0	6.795D-03	6.795D-03	1.957D-03	1.957D-03	6.795D-03	6.601D-03	1.957D-03	1.901D-03	0.0		0.0
28	15	0	2	0	1.198D-01	1.062D-01	1.149D-01	1.110D-01	1.198D-01	1.062D-01	1.149D-01	1.110D-01	1.130D-01		3.553D-01

DIFFERENCE BETWEEN ACCELERATIONS AT T=0 AND RIGID BODY ACCELERATIONS
FOR BALANCED INITIAL CONDITIONS (FROM SUBROUTINE NETFOR)
UNITS ARE G-S AND RAD/SEC-SQ
(LARGEST VALUES SHOWN AT BOTTOM EXCLUDE DRI MASSES)

MASS	XACC	YACC	ZACC	PDOT	QDOT	RDOT
1	-4.561676D-06	0.0	9.702336D-04	0.0	2.066674D-03	0.0
2	4.036447D-09	0.0	-2.070837D-04	0.0	1.833248D-04	0.0
3	2.016033D-06	0.0	-1.999610D-05	0.0	-6.788905D-04	0.0
4	-1.910591D-06	0.0	5.579026D-05	0.0	-3.070369D-04	0.0
5	4.508155D-06	0.0	-5.558921D-05	0.0	-7.724807D-04	0.0
6	-4.443438D-05	0.0	1.124015D-04	0.0	-7.635357D-04	0.0
7	2.852423D-05	0.0	1.653412D-04	0.0	5.425082D-04	0.0
8	2.080692D-04	0.0	-7.058302D-05	0.0	4.254638D-04	0.0
9	-9.796682D-04	0.0	7.811662D-05	0.0	2.739988D-03	0.0
10	8.414123D-05	0.0	-1.444515D-04	0.0	9.046178D-04	0.0
11	-1.503323D-05	2.828370D-06	-6.051263D-05	-3.186850D-04	-3.263788D-04	-6.618038D-06
12	3.432142D-06	-8.641403D-05	-3.306128D-05	5.702816D-04	-1.649016D-05	7.636331D-06
13	5.689057D-05	3.098061D-04	1.011868D-04	-5.093914D-04	1.460003D-04	-1.251510D-04
14	3.723546D-04	-1.525087D-03	-2.186946D-04	-3.208784D-03	1.657369D-03	-5.865503D-04
15	6.044262D-04	1.321402D-03	2.434335D-04	1.497438D-02	-3.419000D-04	-2.276370D-03
16	2.103411D-05	-8.220184D-07	8.313118D-06	-7.573761D-05	-7.339416D-05	-1.573558D-05
17	-2.253260D-04	6.550356D-06	2.671713D-05	4.666457D-04	1.891144D-03	1.748369D-04
18	-1.259608D-06	9.432358D-06	2.926240D-04	1.651754D-03	3.702148D-05	2.360443D-06
19	3.154736D-06	0.0	4.034632D-04	0.0	-8.508533D-05	0.0
20	1.198924D-06	0.0	1.239012D-06	0.0	-2.395068D-06	0.0
21	-1.522104D-02	0.0	9.998829D-01	0.0	-3.320740D-07	0.0
LARGEST VALUE	9.796682D-04	1.525087D-03	9.702336D-04	1.497438D-02	2.739988D-03	2.276370D-03
MASS NO.	9	14	1	15	9	15

FIGURE 2-24. KRASH85 INTERNAL BEAM STRESS DATA AND INITIAL MASS ACCELERATION ERROR OUTPUT (SHEET 2 OF 2)

The reason that the time zero accelerations are not "exactly" equal to the theoretically correct values is because the accuracy of the KRASHIC/MSCTRAN iterations is limited by the number of significant figures used in the input and output data sets used with NASTRAN. The accuracy shown in figure 2-24 is representative of a typical large transport airplane model, using ten iterations of KRASHIC/NASTRAN. In general the results are quite good, with most translational accelerations accurate to within E-5 g's. Errors of this order should have no appreciable influence on the subsequent time history results, particularly for crash impacts which typically involve mass accelerations of five g's or more.

DRI masses are excluded from the largest value summary because the DRI beam elements always start with zero internal load and deflection in the axial direction. In subroutine NETFOR, where the theoretically exact initial accelerations are computed, it is assumed that the DRI mass is rigidly attached to the vehicle.

2.3.3.3 Summary Output

At the conclusion of the time history printout several summaries are presented, which include:

- Summary of internal beam yielding and rupture
- Summary of mass penetration into a control volume
- Summary of external spring loading and unloading
- Summary of plastic hinge moment formations
- Summary of energy distribution
- Time histories of interaction loads/summary of maximum load ratios
- Time histories of vehicle c.g. motions

The summaries are illustrated in figure 2-25.

Internal beam element yielding and rupture are summarized at the end of the run. For each occurrence of yielding or rupture, the time, beam identification and beam direction of yielding or rupture is output. Directions 1-6

correspond to beam axis directions x, y, z, ϕ, Θ and Ψ, the latter three being rotations about the beam x, y and z axes. In addition the beam tension and compression rupture is noted. If a beam has a special KR curve that starts at a nonzero value, then this summary will indicate yielding at time zero. This output provides the user with a concise summary of the onset of beam non-linearities and beam ruptures.

Also included in the internal beam yielding summary are occurrences of interaction loads exceeding the user defined load envelopes. In figure 2-25, SUMMARY OF INTERNAL BEAM YIELDING AND RUPTURE, the first item for beam 18 is a conventional beam yielding in the 1, or axial direction. The second item, for beam 19, is a conventional beam rupture due to exceeding input maximum load levels, again in the axial direction. The third line, for beam 9, is an example of load interaction curve data showing up in this summary. The 15 under YIELD signifies that for load interaction curve number 15, an exceedance of the defined load envelope has occured. The 3 in the right hand column means that load line number 3, for interaction curve 15, was the specific interaction line that was exceeded. If the input load envelope is exceeded by the factor RUPRAT (See Section 2.2, figure 2-3, card 2800), then the load interaction curve number will be printed under the heading RUPTURE. It should be noted that load interaction curve outputs in the YIELD column have caused nothing to happen in the time history solution; outputs in the RUPTURE column would have triggered an actual beam rupture during the time history solution.

Any mass penetrations into the mass penetration control volume are also summarized. Both the mass penetrating the control volume and time of occurrence are noted. Since MVP = 0 in the sample case, this output is not illustrated in figure 2-25.

The summary of external spring loading and unloading provides the time of occurrence, the spring designations (mass, node, direction), type of event, initial deflection, maximum force and unloaded deflection and force.

The summary of plastic hinge formations identifies the time, beam number and mass number at the end where a plastic hinge formation takes place. In figure 2-25, beam 1 and mass 2 goes through cyclic plastic hinge motion. At

SUMMARY OF INTERNAL BEAM YIELDING AND RUPTURE

TIME	BEAM IJ	I	J	M	N	BEAM DIRECTION FOR YIELD	RUPTURE	TENSION(+) OR COMPRESSION(-)
0.030700	18	11	18	3	0	1	0	0
0.071250	19	2	19	1	0	0	1	-1
0.100000	9	9	10	0	0	15	0	3

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 1 OF 10)

SUMMARY OF EXTERNAL SPRING LOADING AND UNLOADING

TYPES;1=INITIAL LOADING 2=MAX.LOADING 3=UNLOAD TO ZERO FORCE 4=INITIATION OF RELOAD

NOTE:SPRING RELOADS AT ZERO FORCE(SEQ.1,2,3,4) OR AT FINITE FORCE VALUE(SEQ.1,2,4)

NOTE:INITIAL DEFLECTION IS FIRST IMPACT IF NYPE=1, OTHERWISE IT IS POINT AT WHICH RELOADING OCCUR FOR NTYPE=4

TIME(SEC)	MASS NO.	NODE NO.	DIRECTION L=1,2,3	TYPE NO.	INITIAL DEFLECTION	MAXIMUM FORCE	&/OR DEFLECT	UNLOADED DEFLECT	& FORCE
0.000050	18	0	3	1	0.0142	0.0	0.0	0.0	0.0
0.027150	19	0	3	1	0.0093	0.0	0.0	0.0	0.0
0.031250	18	0	3	2	0.0142	0.21D 06	5.9281	0.0	0.0
0.031650	18	0	3	2	0.0142	0.21D 06	5.9295	0.0	0.0
0.050700	18	0	3	4	4.8176	0.21D 06	5.9295	4.8176	0.17D 06
0.071350	19	0	3	2	0.0093	0.14D 06	6.5908	0.0	0.0
0.071450	19	0	3	2	0.0093	0.14D 06	6.5906	0.0	0.0
0.075250	19	0	3	3	0.0093	0.14D 06	6.5906	5.2342	0.0
0.080700	18	0	3	2	4.8176	0.33D 06	8.4122	4.8176	0.17D 06
0.080850	18	0	3	2	4.8176	0.33D 06	8.4125	4.8176	0.17D 06
0.097750	18	0	3	4	7.2872	0.33D 06	8.4125	7.2872	0.22D 06

SUMMARY OF PLASTIC HINGE FORMATIONS

TIME	IJ	BEAM I	J	M	N	BEAM END MASS NO.	DIRECTION	-NEWPIN
0.061600	1	1	2	0	0	2	5	1
0.064300	1	1	2	0	0	2	5	0
0.068900	1	1	2	0	0	2	-5	1
0.071600	1	1	2	0	0	2	-5	0
0.072300	1	1	2	0	0	2	5	1

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 2 OF 10)

SUMMARY OF ENERGY DISTRIBUTION

TIME	PERCENT MAXIMUM ENERGY DEVIATION	PERCENT TOTAL SYSTEM ENERGY	KINETIC ENERGY	PERCENT OF CURRENT TOTAL	POTENTIAL ENERGY+	PERCENT OF CURRENT TOTAL	STRAIN ENERGY	PERCENT OF CURRENT TOTAL	DAMPING ENERGY	PERCENT OF CURRENT TOTAL	CRUSHING ENERGY	PERCENT OF CURRENT TOTAL	FRICTION ENERGY	PERCENT OF CURRENT TOTAL
0.0	0.0	100.00	2.405E 09	98.96	2.480E 07	1.02	3.560E 05	0.01	6.407E-11	0.00	0.0	0.0	0.0	0.0
0.01000	0.010961	100.00	2.403E 09	98.91	2.485E 07	1.02	3.586E 05	0.01	5.545E 03	0.00	2.[illegible]84E 05	0.01	9.687E 05	0.04
0.02000	0.009660	100.00	2.400E 09	98.77	2.491E 07	1.03	4.222E 05	0.02	1.142E 05	0.00	8.536E 05	0.04	3.562E 06	0.15
0.03000	0.005369	100.00	2.395E 09	98.58	2.496E 07	1.03	6.989E 05	0.03	4.218E 05	0.02	1.245E 06	0.05	7.152E 06	0.29
0.04000	0.019340	100.00	2.390E 09	98.38	2.502E 07	1.03	1.192E 06	0.05	1.176E 06	0.05	1.089E 06	0.04	1.100E 07	0.45
0.05000	0.018055	100.00	2.385E 09	98.17	2.506E 07	1 03	1.685E 06	0.07	2.278E 06	0.09	9.075E 05	0.04	1.459E 07	0.60
0.06000	0.009878	100.00	2.380E 09	97.95	2.507E 07	1.03	1.989E 06	0.08	2.942E 06	0.12	1.256E 06	0.05	1.846E 07	0.76
0.07000	0.016912	100.00	2.373E 09	97.68	2.507E 07	1.03	1.951E 06	0.08	3.404E 06	0.14	2.181E 06	0.09	2.385E 07	0.98
0.08000	0.020184	100.00	2.366E 09	97.38	2.507E 07	1.03	1.929E 06	0.08	4.100E 06	0.17	2.702E 06	0.11	2.993E 07	1.23
0.09000	0.020185	100.00	2.359E 09	97.09	2.509E 07	1.03	2.327E 06	0.10	5.186E 06	0.21	2.328E 06	0.10	3.566E 07	1.47
0.10000	0.020185	100.00	2.353E 09	96.86	2.511E 07	1.03	3.031E 06	0.12	6.022E 06	0.25	2.112E 06	0.09	4.002E 07	1.65

TIME HISTORIES OF INTERACTION LOADS

LOAD INTERACTION CURVE NO. 1 , BEAM NO. 1
LOCATION: FS= 300.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	1.4432E 03	1.4575E 05	1.0449E-02
0.01000000	1	1.4505E 03	1.4606E 05	1.0492E-02
0.02000000	1	1.2069E 03	1.5838E 05	9.5379E-03
0.03000000	8	4.1271E 01	-1.5248E 04	7.3306E-04
0.04000000	2	5.8028E 02	-7.8524E 04	4.6380E-03
0.05000000	5	8.2173E 02	-7.3234E 03	4.9502E-03
0.06000000	8	-1.2858E 02	-7.0516E 04	3.3902E-03
0.06999999	1	4.2607E 03	1.9882E 05	2.5771E-02
0.07999998	7	-5.9770E 03	-1.8445E 05	3.6006E-02
0.08999997	2	2.8527E 03	-1.8420E 05	1.8375E-02
0.09999996	8	-9.0518E 02	-1.8431E 05	8.8610E-03
MAXIMUM VALUE:		4.2607E 03	1.9882E 05	3.6006E-02
MINIMUM VALUE:		-5.9770E 03	-1.8445E 05	

LOAD INTERACTION CURVE NO. 2 , BEAM NO. 2
LOCATION: FS= 300.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	5	1.0825E 04	1.4968E 05	6.5209E-02
0.01000000	5	1.0887E 04	1.4649E 05	6.5583E-02
0.02000000	1	7.0436E 03	4.0998E 05	4.4386E-02
0.03000000	6	3.2890E 01	4.7372E 04	2.2775E-03

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 3 OF 10)

0.04000000	8	-6.8032E 03	-1.3475E 06	6.4784E-02
0.05000000	7	-2.5080E 04	2.6355E 04	1.5109E-01
0.06000000	7	-4.6627E 04	5.3843E 05	2.8089E-01
0.06999999	7	-6.5402E 04	-1.3806E 06	3.9399E-01
0.07999998	8	2.5365E 02	-6.7244E 06	3.2329E-01
0.08999997	2	5.0925E 03	-8.4343E 05	4.4087E-02
0.09999996	1	2.7333E 04	1.7523E 06	1.7578E-01
	MAXIMUM VALUE:	2.7333E 04	1.7523E 06	3.9399E-01
	MINIMUM VALUE:	-6.5402E 04	-6.7244E 06	

LOAD INTERACTION CURVE NO. 3 , BEAM NO. 2
LOCATION: FS= 400.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	1.0825E 04	1.2341E 06	7.8810E-02
0.01000000	1	1.0887E 04	1.2371E 06	7.9195E-02
0.02000000	1	7.0436E 03	1.1156E 06	5.6423E-02
0.03000000	10	3.2890E 01	5.0668E 04	2.1289E-03
0.04000000	8	-6.8032E 03	-2.0291E 06	8.9974E-02
0.05000000	5	-2.5080E 04	-2.4863E 06	1.7646E-01
0.06000000	5	-4.6627E 04	-4.1329E 06	3.2001E-01
0.06999999	5	-6.5402E 04	-7.9327E 06	4.8400E-01
0.07999998	12	2.5365E 02	-6.6995E 06	2.8149E-01
0.08999997	3	5.0925E 03	-3.3379E 05	3.3017E-02
0.09999996	1	2.7333E 04	4.4902E 06	2.2160E-01
	MAXIMUM VALUE:	2.7333E 04	4.4902E 06	4.8400E-01
	MINIMUM VALUE:	-6.5402E 04	-7.9327E 06	

LOAD INTERACTION CURVE NO. 4 , BEAM NO. 3
LOCATION: FS= 480.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	2.3901E 04	2.3625E 06	1.4070E-01
0.01000000	1	2.3359E 04	2.3918E 06	1.3814E-01
0.02000000	1	2.0812E 04	1.8557E 06	1.2097E-01
0.03000000	1	1.7145E 04	1.3406E 05	8.8953E-02
0.04000000	3	1.7726E 04	-1.8144E 06	1.0483E-01
0.05000000	6	5.3162E 03	-4.2486E 06	1.5676E-01
0.06000000	6	1.2085E 04	-7.8305E 06	2.9311E-01
0.06999999	6	5.4359E 04	-1.0317E 07	4.5667E-01
0.07999998	6	3.5852E 04	-4.7208E 06	2.2910E-01
0.08999997	1	3.8774E 04	4.5970E 05	2.0237E-01
0.09999996	2	5.1361E 04	7.1999E 06	3.4332E-01
	MAXIMUM VALUE:	5.4359E 04	7.1999E 06	4.5667E-01
	MINIMUM VALUE:	0.0	-1.0317E 07	

LOAD INTERACTION CURVE NO. 5 , BEAM NO. 3
LOCATION: FS= 540.000 , BL= 0.0 , WL= 0.0

CRITICAL LOAD X LOAD Y LOAD MAX. LOAD

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 4 OF 10)

TIME	LINE NUMBER	(NO. 3)	(NO. 5)	RATIO
0.0	1	2.3901E 04	3.7968E 06	1.4776E-01
0.01000000	1	2.3359E 04	3.7935E 06	1.4501E-01
0.02000000	1	2.0812E 04	3.1045E 06	1.2719E-01
0.03000000	1	1.7145E 04	1.1629E 06	9.4626E-02
0.04000000	3	1.7726E 04	-7.5068E 05	9.4544E-02
0.05000000	6	5.3162E 03	-3.9297E 06	1.1522E-01
0.06000000	6	1.2085E 04	-7.1054E 06	2.1014E-01
0.06999999	3	5.4359E 04	-7.0553E 06	3.2455E-01
0.07999998	3	3.5852E 04	-2.5697E 06	1.9888E-01
0.08999997	1	3.8774E 04	2.7860E 06	2.1514E-01
0.09999996	1	5.1361E 04	1.0282E 07	3.3298E-01
MAXIMUM VALUE:		5.4359E 04	1.0282E 07	3.3298E-01
MINIMUM VALUE:		0.0	-7.1054E 06	

LOAD INTERACTION CURVE NO. 6 , BEAM NO. 3
LOCATION: FS= 620.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	2	2.3901E 04	5.7091E 06	1.3381E-01
0.01000000	2	2.3359E 04	5.6624E 06	1.3181E-01
0.02000000	2	2.0812E 04	4.7697E 06	1.1399E-01
0.03000000	2	1.7145E 04	2.5347E 06	7.6405E-02
0.04000000	1	1.7726E 04	6.6759E 05	6.5577E-02
0.05000000	12	5.3162E 03	-3.5045E 06	7.7877E-02
0.06000000	12	1.2085E 04	-6.1387E 06	1.3641E-01
0.06999999	3	5.4359E 04	-2.7067E 06	2.0465E-01
0.07999998	9	3.5852E 04	2.9855E 05	1.3085E-01
0.08999997	2	3.8774E 04	5.8878E 06	1.7474E-01
0.09999996	10	5.1361E 04	1.4391E 07	3.1979E-01
MAXIMUM VALUE:		5.4359E 04	1.4391E 07	3.1979E-01
MINIMUM VALUE:		0.0	-6.1387E 06	

LOAD INTERACTION CURVE NO. 7 , BEAM NO. 4
LOCATION: FS= 620.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	2	3.1956E 04	5.7088E 06	1.5476E-01
0.01000000	2	3.2378E 04	5.5424E 06	1.5377E-01
0.02000000	1	3.9180E 04	4.3801E 06	1.6059E-01
0.03000000	1	4.5518E 04	2.3272E 06	1.7169E-01
0.04000000	9	3.4936E 04	5.9864E 05	1.2750E-01
0.05000000	[illegible]	5.8597E 04	-3.8165E 06	2.2545E-01
0.06000000	3	1.0030E 05	-6.3104E 06	3.8471E-01
0.06999999	9	1.0682E 05	-2.3249E 06	3.8985E-01
0.07999998	9	1.0936E 05	-6.6179E 05	3.9914E-01
0.08999997	1	1.1516E 05	5.6730E 06	4.3322E-01
0.09999996	2	8.7665E 04	1.3921E 07	4.0273E-01
MAXIMUM VALUE:		1.1516E 05	1.3921E 07	4.3322E-01
MINIMUM VALUE:		0.0	-6.3104E 06	

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 5 OF 10)

LOAD INTERACTION CURVE NO. 8 , BEAM NO. 5
LOCATION: FS= 960.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	2.6029E 04	1.3903E 07	1.8948E-01
0.01000000	1	3.3438E 04	1.3620E 07	1.8410E-01
0.02000000	7	7.7627E 04	1.3860E 07	2.6954E-01
0.03000000	7	1.4105E 05	1.9478E 07	4.8975E-01
0.04000000	7	1.4238E 05	3.0446E 07	4.9932E-01
0.05000000	2	1.7177E 05	3.6874E 07	6.0333E-01
0.06000000	7	2.2831E 05	4.1785E 07	7.9275E-01
0.06999999	2	1.9131E 05	4.7063E 07	7.1118E-01
0.07999998	1	8.7044E 04	5.3087E 07	7.2583E-01
0.08999997	1	1.5296E 05	5.0584E 07	6.7823E-01
0.09999996	2	2.4960E 05	5.6226E 07	8.9400E-01
MAXIMUM VALUE:		2.4960E 05	5.6226E 07	8.9400E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 9 , BEAM NO. 6
LOCATION: FS= 960.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	3.9303E 04	1.4143E 07	1.9029E-01
0.01000000	1	4.1318E 04	1.4114E 07	1.8950E-01
0.02000000	2	6.3622E 04	1.4524E 07	2.2913E-01
0.03000000	7	1.1614E 05	1.9357E 07	4.0326E-01
0.04000000	7	1.4935E 05	3.0596E 07	5.1859E-01
0.05000000	2	1.6815E 05	3.8531E 07	6.0653E-01
0.06000000	2	2.0004E 05	4.2754E 07	7.0138E-01
0.06999999	2	1.7822E 05	4.8462E 07	6.9276E-01
0.07999998	1	1.1828E 05	5.6003E 07	7.6065E-01
0.08999997	1	1.2390E 05	5.3240E 07	7.2094E-01
0.09999996	2	1.9407E 05	5.8359E 07	7.9092E-01
MAXIMUM VALUE:		2.0004E 05	5.8359E 07	7.9092E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 10 , BEAM NO. 6
LOCATION: FS=1000.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	1	3.9303E 04	1.2568E 07	1.8553E-01
0.01000000	1	4.1318E 04	1.2459E 07	1.9174E-01
0.02000000	1	6.3622E 04	1.1974E 07	2.6373E-01
0.03000000	9	1.1614E 05	1.4703E 07	4.5724E-01
0.04000000	1	1.4935E 05	2.4612E 07	6.0381E-01
0.05000000	1	1.6815E 05	3.1794E 07	6.9765E-01
0.06000000	1	2.0004E 05	3.4739E 07	8.1640E-01
0.06999999	1	1.7822E 05	4.1321E 07	7.7277E-01

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 6 OF 10)

0.07999998	2	1.1828E 05	5.1263E 07	6.9592E-01
0.08999997	2	1.[illegible]E 05	4.8276E 07	6.6458E-01
0.09999996	1	1.9407E 05	5.0583E 07	8.6592E-01
MAXIMUM VALUE:		2.0004E 05	5.1263E 07	8.6592E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 11 , BEAM NO. 7
LOCATION: FS=1080.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	3	2.3983E 04	1.0029E 07	1.7194E-01
0.01000000	3	2.3995E 04	1.0004E 07	1.7155E-01
0.02000000	2	2.5504E 04	9.0994E 06	1.6228E-01
0.03000000	2	4.5198E 04	8.5146E 06	2.1695E-01
0.04000000	2	8.9251E 04	1.4050E 07	4.0275E-01
0.05000000	2	1.0990E 05	2.0777E 07	5.2819E-01
0.06000000	2	1.0782E 05	2.1828E 07	5.3159E-01
0.06999999	2	1.0645E 05	2.9461E 07	5.9827E-01
0.07999998	2	1.1290E 05	4.1935E 07	7.3371E-01
0.08999997	3	8.0235E 04	4.3049E 07	7.2362E-01
0.09999996	3	9.6245E 04	3.9365E 07	6.7623E-01
MAXIMUM VALUE:		1.1290E 05	4.3049E 07	7.3371E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 12 , BEAM NO. 7
LOCATION: FS=1160.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	3	2.3983E 04	8.0998E 06	1.9212E-01
0.01000000	3	2.3995E 04	8.0736E 06	1.9161E-01
0.02000000	3	2.5504E 04	7.0481E 06	1.7293E-01
0.03000000	2	4.5198E 04	4.8792E 06	1.7986E-01
0.04000000	1	8.9251E 04	6.8714E 06	3.4757E-01
0.05000000	2	1.0990E 05	1.1939E 07	4.3823E-01
0.06000000	2	1.0782E 05	1.3156E 07	4.4723E-01
0.06999999	3	1.0645E 05	2.0900E 07	5.5110E-01
0.07999998	3	1.1290E 05	3.2855E 07	7.9869E-01
0.08999997	3	8.0235E 04	3.6596E 07	8.3308E-01
0.09999996	3	9.6245E 04	3.1624E 07	7.5333E-01
MAXIMUM VALUE:		1.1290E 05	3.6596E 07	8.3308E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 13 , BEAM NO. 8
LOCATION: FS=1240.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	12	9.1594E 03	6.7598E 06	1.9314E-01
0.01000000	12	9.1269E 03	6.7581E 06	1.9309E-01

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 7 OF 10)

0.0[illegible]	12	6.9136E 03	6.5[illegible]E 06	1.8579E-01
0.0[illegible]	12	9.6964E 02	4.6[illegible]E 06	1.5[illegible]E-01
0.0[illegible]	2	1.1509E 04	2.2[illegible]E 06	7.4301E-02
0.0[illegible]000	2	3.3667E 04	4.2377E 06	1.6614E-01
0.0[illegible]000	3	2.0969E 04	9.4567E 06	2.7731E-01
0.06[illegible]	3	4.1532E 04	1.6141E 07	4.7927E-01
0.07999998	3	7.7620E 04	2.2334E 07	6.8404E-01
0.08999997	3	7.9260E 04	2.9386E 07	8.7635E-01
0.09999996	3	4.959[illegible]E 04	3.0264E 07	8.6933E-01
MAXIMUM VALUE:		7.9260E 04	3.0264E 07	8.7635E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 14 , BEAM NO. 8
LOCATION: FS=1320.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	8	9.1594E 03	6.0106E 06	2.2098E-01
0.01000000	8	9.1269E 03	6.0115E 06	2.2101E-01
0.02000000	8	6.9136E 03	5.9372E 06	2.1828E-01
0.03000000	8	9.6964E 02	4.6036E 06	1.6943E-01
0.04000000	1	1.1809E 04	1.3188E 06	6.5427E-02
0.05000000	1	3.3667E 04	1.4842E 06	2.1132E-01
0.06000000	8	2.0969E 04	7.7417E 06	2.8462E-01
0.06999999	8	4.1532E 04	1.2744E 07	4.6854E-01
0.07999998	2	7.7620E 04	1.5986E 07	6.1986E-01
0.08999997	8	7.9260E 04	2.2904E 07	8.4206E-01
0.09999996	8	4.9596E 04	2.6208E 07	9.6353E-01
MAXIMUM VALUE:		7.9260E 04	2.6208E 07	9.6353E-01
MINIMUM VALUE:		0.0	0.0	

LOAD INTERACTION CURVE NO. 15 , BEAM NO. 9
LOCATION: FS=1400.000 , BL= 0.0 , WL= 0.0

TIME	CRITICAL LOAD LINE NUMBER	X LOAD (NO. 3)	Y LOAD (NO. 5)	MAX. LOAD RATIO
0.0	3	2.3090E 04	4.0092E 06	2.3738E-01
0.01000000	3	2.3089E 04	4.0089E 06	2.3736E-01
0.02000000	3	2.2937E 04	4.0195E 06	2.3775E-01
0.03000000	3	1.8054E 04	3.3308E 06	1.9598E-01
0.04000000	1	8.2390E 03	3.4136E 05	6.0506E-02
0.05000000	1	1.2675E 04	-6.3077E 05	1.1410E-01
0.06000000	3	3.0562E 04	5.6778E 06	3.3385E-01
0.06999999	3	4.8597E 04	8.9195E 06	5.2507E-01
0.07999998	3	6.1157E 04	1.0009E 07	5.9621E-01
0.08999997	3	8.3528E 04	1.5607E 07	9.1709E-01
0.09999996	3	8.9178E 04	2.0268E 07	1.1699E 00
MAXIMUM VALUE:		8.9178E 04	2.0268E 07	1.1699E 00
MINIMUM VALUE:		0.0	-6.3077E 05	

SUMMARY OF MAXIMUM LOAD RATIOS

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 8 OF 10)

INTERACTION CURVE NO.	BEAM NO.	INT. CURVE LOCATION FS	BL	WL	MAXIMUM LOAD RATIO
1	1	300.000	0.0	0.0	3.6006E-02
2	2	300.000	0.0	0.0	3.9399E-01
3	2	400.000	0.0	0.0	4.8400E-01
4	3	480.000	0.0	0.0	4.5667E-01
5	3	540.000	0.0	0.0	3.3298E-01
6	3	620.000	0.0	0.0	3.1979E-01
7	4	620.000	0.0	0.0	4.3322E-01
8	5	960.000	0.0	0.0	8.9400E-01
9	6	960.000	0.0	0.0	7.9092E-01
10	6	1000.000	0.0	0.0	8.6592E-01
11	7	1080.000	0.0	0.0	7.3371E-01
12	7	1160.000	0.0	0.0	8.3308E-01
13	8	1240.000	0.0	0.0	8.7635E-01
14	8	1320.000	0.0	0.0	9.6353E-01
15	9	1400.000	0.0	0.0	1.1699E 00

OVERALL MAXIMUM LOAD RATIO = 1.1699E 00
CORRESPONDING INT. CURVE NO.= 15

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 9 OF 10)

TIME HISTORIES OF VEHICLE CG MOTIONS

TIME	DXI VXI	DYI VYI	DZI VZI	FXI AXI	FYI AYI	FZI AZI
0.0	0.0	0.0	0.0	7.16227D-12	0.0	-4.54747D-12
	3.14000D 03	0.0	3.00000D 02	-9.88461D-03	0.0	2.21054D-02
0.010000	3.13976D 01	0.0	2.99302D 00	5.96861D 04	0.0	1.98954D 05
	3.13932D 03	0.0	2.97963D 02	-3.30717D-01	0.0	-1.04434D 00
0.020000	6.27826D 01	0.0	5.94653D 00	1.05983D 05	0.0	3.53277D 05
	3.13753D 03	0.0	2.92227D 02	-5.79321D-01	0.0	-1.87156D 00
0.030000	9.41457D 01	0.0	8.82912D 00	1.29544D 05	0.0	4.31816D 05
	3.13501D 03	0.0	2.84048D 02	-7.05133D-01	0.0	-2.29257D 00
0.040000	1.25482D 02	0.0	1.16250D 01	1.23940D 05	0.0	4.13134D 05
	3.13230D 03	0.0	2.75235D 02	-6.73781D-01	0.0	-2.19246D 00
0.050000	1.56793D 02	0.0	1.43366D 01	1.13817D 05	0.0	3.79396D 05
	3.12984D 03	0.0	2.67220D 02	-6.17434D-01	0.0	-2.01165D 00
0.060000	1.88079D 02	0.0	1.69683D 01	1.36810D 05	0.0	4.56036D 05
	3.12729D 03	0.0	2.58889D 02	-7.38212D-01	0.0	-2.42251D 00
0.070000	2.19335D 02	0.0	1.95022D 01	2.02074D 05	0.0	6.73580D 05
	3.12373D 03	0.0	2.47167D 02	-1.08618D 00	0.0	-3.58865D 00
0.080000	2.50551D 02	0.0	2.19053D 01	1.98194D 05	0.0	6.60648D 05
	3.11965D 03	0.0	2.33676D 02	-1.06490D 00	0.0	-3.51937D 00
0.090000	2.81728D 02	0.0	2.41760D 01	1.60565D 05	0.0	5.35217D 05
	3.11580D 03	0.0	2.20964D 02	-8.63368D-01	0.0	-2.84706D 00
0.100000	3.12871D 02	0.0	2.63361D 01	1.34529D 05	0.0	4.48435D 05
	3.11290D 03	0.0	2.11426D 02	-7.23725D-01	0.0	-2.38189D 00

FIGURE 2-25. KRASH85 SUMMARY OUTPUT DATA (SHEET 10 OF 10)

t = .0616, NEWPIN = 1 signifies that the coding has changed from fixed at the j end to pinned at the j end (j = 2). This is the technique for forming a plastic hinge. At t = .0643, NEWPIN = 0 signifies that unloading has occurred, so that a fixed end condition is appropriate. Subsequent changes in NEWPIN define transition points on a hysteresis curve. NEWPIN = 0 always means a transition to fixed coding has taken place, due to unloading from a plastic hinge moment. NEWPIN = 1 always means that a transition to pinned coding has taken place, due to exceeding the input plastic hinge moment. DIRECTION = 5 in Figure 2-23 refers to moments about the y beam axis (6 would be moment about the z beam axis). DIRECTION = -5 means that the sign of the plastic hinge moment at that time is negative.

The energy summary showing the time variation of the different types of energy is presented. This summary facilitates visualizing the energy flow time variation; the one or two page summary is much easier to read than skimming through the basic time history print, which can run to hundreds of pages. Figure 2-25 shows an example of this output for the sample case. A quick glance at the "PERCENT TOTAL SYSTEM ENERGY" column tells the user how stable the solution is. The percent energy should stay within 99 - 101 percent, *preferably within* a ± 0.2 percent band. Any significant system instabilities will quickly manifest themselves in this output.

The column entitled "PERCENT MAXIMUM ENERGY DEVIATION" shows the maximum deviation from 100 percent of the total energy for each mass individually, i.e., at each time the worst deviation of all the masses is shown. These numbers will always indicate a greater departure from 100 percent than the "PERCENT TOTAL SYSTEM ENERGY" column, wherein all the masses constituting the system are included. The reason for this situation is that some of the masses have positive and some negative deviations from 100 percent, and when these are summed over the total system cancellations occur. Individual mass total energy deviations in the order of 10 percent may be tolerable, as long as the total system energy is acceptable. In the example shown in figure 2-25, the total system energy remains constant within .01 percent, while the maximum energy deviation is .02 percent at the conclusion of the analysis. The (+) in the heading for POTENTIAL ENERGY signifies that energy changes due to

applied force or acceleration input time histories are included in the numbers shown (refer to Section 2.2.4.2.5).

Time histories of interaction loads follow the energy summary. In the sample case, there are 15 of these time histories, requiring about 5½ pages of output. For each load interaction curve number, the following information is presented versus time:

- X load value, pounds or inch-pounds
- Y load value, pounds or inch-pounds
- Critical load line number. Of all the straight line segments making up the load envelope, the one which is most critical relative to the current X,Y combined loads is indicated. In general, the critical load line number will change with time as the X and Y loads change.
- Maximum load ratio. This is the ratio by which the current load vector length (pt. 0,0 to point X,Y) exceeds a line along this vector but terminating at the intersection of the vector and the critical load line (input). A ratio greater than 1.0 signifies an excursion outside the load envelope defined in the input data.

Each time history data block also includes the identification of the load interaction curve number, beam number and location (FS, BL and WL). Also, the directions of the X and Y loads are defined. In the sample case, the X load is always 3 (vertical shear, Fz) and the Y load is always 5 (bending moment about 7 axis). At the end of each time history data block, the maximum and minimum values of X load and Y load are shown, as well as the peak value of MAX.LOAD RATIO.

After the individual load interaction time histories, a summary of the peak values of the maximum load ratio is shown for all the input curves. This is followed by the overall maximum load ratio and the corresponding interaction curve number. For example, in figure 2-25, the overall maximum load ratio is 1.1699, which occurs for interaction curve number 15. This output gives a very quick indication of the severity of the impact being analyzed. However, maximum load ratios greater than 1.0 do not necessarily imply that the corresponding structural section would have completely failed. Refer to Section 3.1 for a discussion of the theory and usage of the load-interaction data.

If the interaction curves are used to obtain an overall section shear and moment (summation of all loads acting at a particular station) then the aforementioned printed summary is applicable to the sum of the forces acting and not an individual beam.

The final summary print output is a time history of the overall vehicle c.g. motions. The quantities included are

- c.g. translational accelerations, g's
- c.g. translational velocities, in/sec
- c.g. translational displacements, in (= 0 at time = 0)
- Net forces acting at the c.g., pounds

All these data are calculated in the same manner as the c.g. translational velocities, described in Section 1.3.9 of Volume 1. Weighted averages of all the mass motions are used to arrive at a value for the entire system. The final results completely define the translational motions of an uncoupled 1-mass, 3 degree-of-freedom system. Rotational loads and motions are not presented.

These data have been used to determine vertical load-deflection characteristics for a large transport frame structure. Cross plots of DZI vs FZI from the KRASH analysis of a frame structure form a load-deflection curve that can be used to determine the external spring characteristics of a stick model of an entire airplane.

2.3.3.4 Time History Plots

The final section of output data consists of time history plots of selected response quantities. Figure 2-26 illustrates typical output data. The sequential time history print of the three responses is shown on the left, while the plots are generated using three separate printer symbols. The scale factor for all three plots is shown in the upper right corner of the page. The plot summary is printed on a separate output page as are the various sets of data.

BEAM 11 I,M = 11, 1 J,N = 12, 0 AXIAL AND SHEAR FORCES(LB)

SCALE FACTOR = 1.760E 04

TIME(SEC)	FX *	FY =	FZ +
0.0	1.118E 05	2.958E 04	-2.167E 04
0.010	1.052E 05	2.512E 04	-1.221E 04
0.020	8.173E 04	1.556E 04	1.089E 04
0.030	6.175E 04	7.573E 03	1.665E 04
0.040	4.526E 04	5.869E 03	1.412E 04
0.050	8.538E 03	-6.437E 03	3.082E 04
0.060	-1.183E 04	-1.947E 04	3.329E 04
0.070	-1.048E 04	-7.815E 03	1.572E 04
0.080	9.491E 02	1.251E 04	6.732E 03
0.090	4.979E 03	4.551E 03	3.533E 04
0.100	2.677E 04	-3.599E 04	7.308E 04

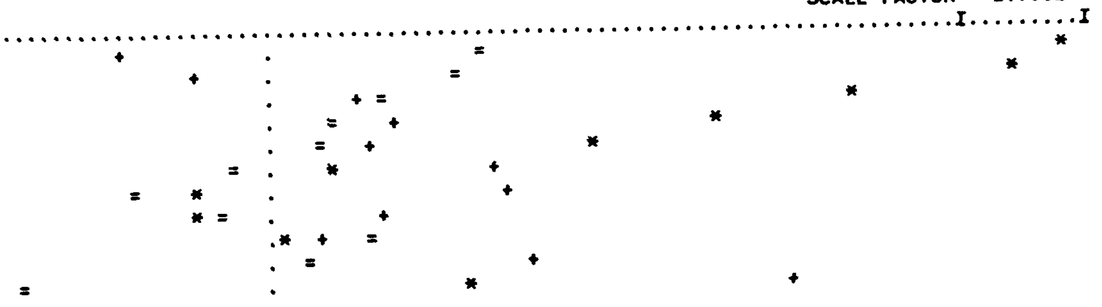

FIGURE 2-26. KRASH85 SAMPLE OUTPUT TIME HISTORY PLOTS

SECTION 3

ADDITIONAL KRASH85 DATA REQUIREMENTS

This sections contains a description of those KRASH data requirements that are needed for KRASH85. These requirements are in addition to those items provided in Section 4 of reference 2.

3.1 LOAD-INTERACTION CURVES

KRASH85 has provisions to include load interaction curve data for failure prediction. Figure 3-1 shows a typical set of interaction curves for fuselage bending and shear at a particular airplane fuselage station. Figure 3-2 identifies the stringers at a representative frame location. The input requirements for load-interaction curves are as follows:

- The user can specify interaction curves at a maximum of 40 locations, which can be anywhere. For each curve, either a Fuselage Station, Butt Line, or Water Line (only one) is input, as well as the corresponding beam number in a KRASH model. The location of the interaction curve can be anywhere along a given beam; the user is not restricted to using the end points of the beam. For essentially fore-aft beams, only F.S. is input, while for lateral and vertical beams B.L. and W.L., respectively, are input to define the location of a load interaction curve. For each load interaction curve, the user inputs the following additional information:

    - The two load directions for the interaction curve. In figure 3-1, the abscissa represents vertical shear (direction 3) and the ordinate represents vertical bending moment (direction 5). Any 2 of the 6 loads can be specified.

    - A user-specified load sign convention.

    - Horizontal and vertical load interaction lines (4 total).

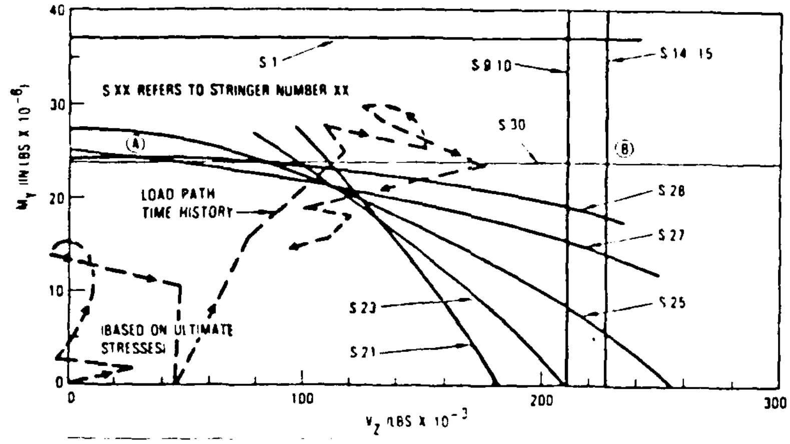

FIGURE 3-1. MAXIMUM ALLOWABLE MOMENT AND SHEAR ENVELOPE - NEGATIVE BENDING

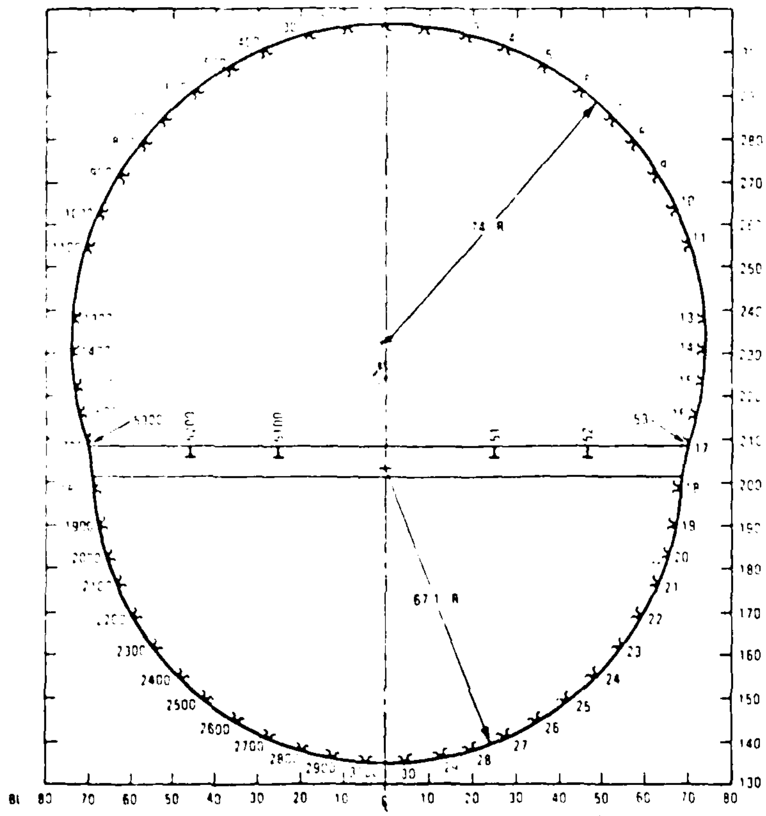

FIGURE 3-2. TYPICAL CROSS SECTION WITH STIFFENER LOCATIONS - REAR VIEW

- Up to 20 straight, sloping load interaction lines. The x and y axis intercepts are input for each line.

- A quantity called RUPRAT (rupture ratio), which is explained below.

The program is coded so that for the sloping interaction lines, data are input for any one quadrant (x and y axis intercepts). In addition, "mirror flags" are input to tell the program whether or not to generate mirror image lines about the x and/or y axes. For example, in figure 3-3 the data are input for line 1 (x and y intercepts), and both the x and y axis mirror flags are input as 1. The program then automatically generates lines 2, 3, and 4. If only a mirror about the y axis had been specified, then the program would generate only line 2.

At each location the program calculates the following:

- The internal beam loads, in KRASH sign convention, at the load interaction point.

  - These loads are transformed to correspond to the standard structural load sign convention employed by the Lockheed-California Company (Calac), shown in figure 3-4.

  - The Calac-convention loads are then transformed to a user-specified sign convention. One of ten such sign conventions may be selected by the user. If no convention is specified, the loads are left in the Calac sign convention.

  - The two interaction loads are selected from the 6 loads calculated.

- A load ratio for each load interaction line. A ratio greater than one indicates that a load interaction curve has been exceeded, signifying that at least one element has failed in some manner. KRASH is coded to allow complete rupture of a beam element if an input maximum load ratio (RUPRAT) is exceeded.

  1. A left handed coordinate system is used; moments employ left hand rule.

  2. Internal loads and moments are positive if the loads or moments applied by the part with the greater algebraic coordinate are positive in accordance with body axes conventions shown as x, y, z.

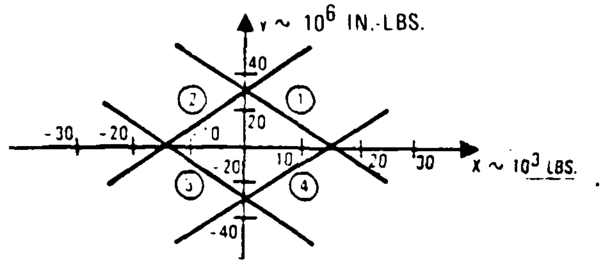

FIGURE 3-3. GENERATION OF LOAD-INTERACTION CURVES

Application of these rules to fuselage and wing loads are shown in the following sketch:

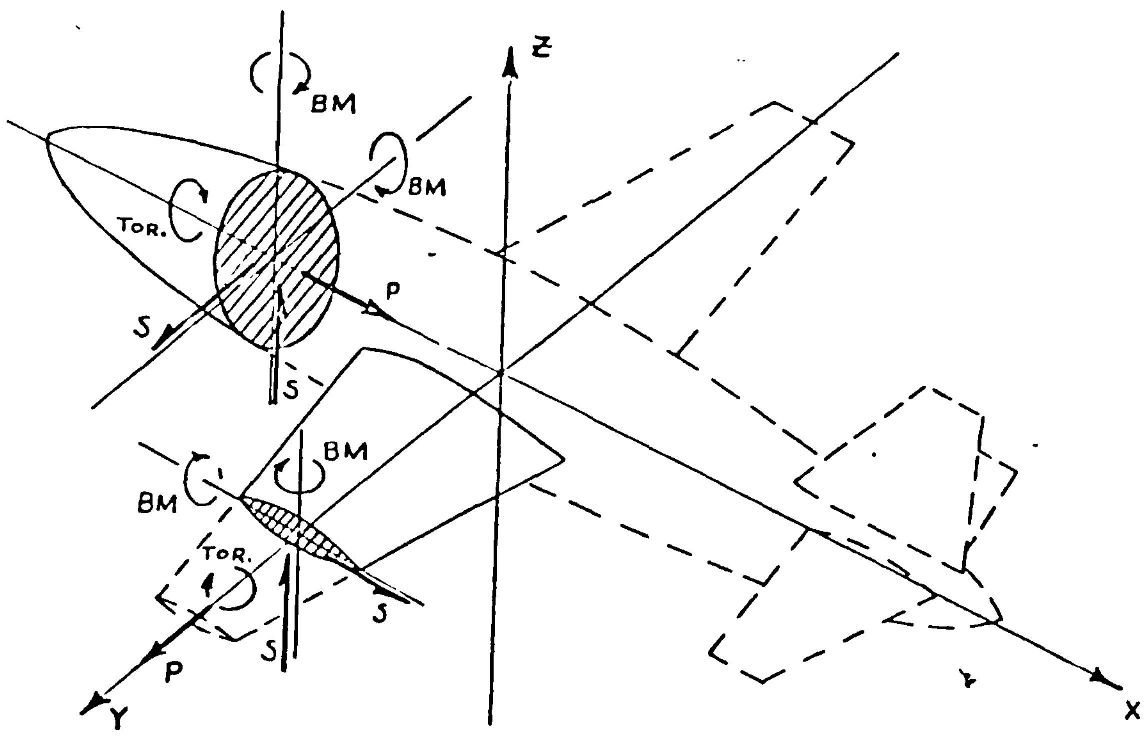

FIGURE 3-4. LOCKHEED LOAD SIGN CONVENTIONS

Loads shown are those applied to the cutplane by the parts with the greater algebraic coordinate (station).

At the conclusion of the computer run the following is printed:

- Time histories of the following quantities for each load interaction curve.
  - X Load (fuselage vertical shear in figure 3-1).
  - Y Load (fuselage vertical bending in figure 3-1).
  - Maximum load ratio at each time.
  - Input load interaction line number corresponding to the maximum load ratio at that time.
- A summary which shows the peak maximum load ratio for each interaction curve and the overall maximum load ratio.

The user has the option of saving the load-interaction curve time history data in an output file, which can be used for subsequent post-processing. These data can be plotted to show the time-varying path of the calculated x-y loads, superimposed on the load-interaction curve (as illustrated by the dashed lines in figure 3-1).

While the load interaction data output provides a great deal of useful information not previously available, considerable caution must be exercised by the user in its interpretation. A maximum load ratio greater than one does not, by itself, indicate complete failure of the corresponding fuselage section. The output data have been used in conjunction with the actual manufacturer-furnished interaction diagrams to assess the extent of damage at each location. For example, suppose that the computed combined loads were as shown by points A or B in figure 3-1. For point A stringers S27 through S30 could fail. For point B several additional stringer elements could fail (S-9 through S-15 and S-21 through S-30). Usually the input data to KRASH is the minimum necessary to define the inner boundary in figure 3-1. The current KRASH85 coding does not define which stringers fail; it only defines the critical load line at each time out.

3.2 ARBITRARY MASS NUMBERING

Program KRASH has been modified to accept user supplied mass point identification numbers. The modification can be thought of conceptually as a mass point number pre-processor and a mass point number post-processor. The pre-processor converts external mass point numbers to internal mass point numbers. The external mass point numbers are supplied by the user as part of the input while the internal mass point numbers are defined by the program. The internal mass numbers are consistent with the numbering system previously used in earlier versions of program KRASH. After conversion program KRASH85 is executed using the internal mass point numbers. After execution is completed the post-processor converts the internal mass point numbers to external mass point numbers for output. In the modification, two new subroutines (INPT and INPTPL) were added. In these subroutines, two arrays (MASS and IMASS) are defined which cross reference the external mass point numbers to internal mass point numbers and vice versa.

The external mass point identification numbers are input in column 71 and 72 on Card 200 (MASS POINT DATA). The identification numbers can not be less than zero or greater than 99. If they are, program execution will be halted. If any of the numbers are left blank or set equal to zero, the program will automatically assign sequential identification numbers to all mass points in the order of input. This option accommodates previously developed input data sets.

When the RUNMOD=2 option is used, the program automatically assigns an external mass point identification number to the image mass point generated under this option. The identification number assigned is 100 greater than the identification number of the mass point used in defining the image mass point. For example, if the input mass point identification number is 96 then the image mass point identification number will be 196.

SECTION 4

COMMON BLOCK REGIONS

KRASH85 is designed such that data storage and transfer is accomplished using the many common block regions defined within the program. A cross reference of the common block names and using subroutines is given in Table 4-1. Included in the cross reference summary are size requirements defined by the FORTRAN H/EXTENDED (OPT = 3) compiler.

TABLE 4-1. KRASH85 SUBROUTINE/COMMON REGION REFERENCE

SUBROUTINE / COMMON REGION	REGION SIZE	ACCELT	ACCEN	BEAM	CFORCF	DEPTV	DOAIJ	GENMOD	IC	ICINPT	INPRNT	INPRT1	INPT	INPTPL	INPUT	INTERP	KVR	LTCALC	MATN	MOCXDP	NFTFOP	PRFPLT	PRTNT	RSIN	RSOUT	SMLOAD
ACCEDE	30		*			*																				
ACCEIR	280		*			*					*															
ACCSAV	C8F4			*		*		*			*				*			*	*							
ACCSV1	10			*		*		*			*				*			*	*							
AERO1	104C			*		*		*			*				*			*					*			
AERO2	F00			*		*												*					*			
AFENER	280		*			*													*					*	*	
AIJIC	4						*												*							
AVDF	28A4			*		*												*	*							
AVDFRS	780					*																		*	*	
BEAMDE	4210			*		*			*									*	*					*	*	
BKMOD	4			*											*											
BLANK	9980			*		*												*	*		*			*	*	
BOMB	4														*				*							
CFIC	58				*				*												*					
CFINPU	140				*			*			*				*											
CFIP	640				*						*															
CFPR	840				*																		*	*	*	
COMALL	1C088		*	*	*	*	*	*	*		*				*		*	*	*	*	*		*	*	*	*
COMMI2	8D4							*			*				*		*									
COMMI4	938							*			*				*		*		*	*	*			*	*	
COMMR4	2FD0							*			*				*											
COMMR8	4B0							*			*				*											
COMNEW	18							*	*		*				*		*		*							
DFIC	260			*		*			*									*			*		*			*
DEIN	1022C		*	*		*		*			*				*			*			*		*	*	*	
DFINPR	48B0			*		*	*	*	*		*				*		*	*			*		*			
DFIR	12C0			*		*					*							*								
DEMA	8			*		*												*					*			
DEPR	67B0			*		*												*					*	*	*	
DINICP	2044			*		*		*	*		*	*			*		*	*			*		*	*	*	
DCIN	4B0			*		*	*	*			*				*		*	*								
DRIFLG	140								*												*		*			
DRIMAS	140			*		*					*							*								
ENERGY	16B8			*		*												*					*	*	*	
FBPLT	C8														*							*	*			
FLGSET	5C			*		*													*							
FSIJIJ	3840			*																			*	*	*	*
GRASAV	8			*		*									*			*	*							

TABLE 4-1. KRASH85 SUBROUTINE/COMMON REGION REFERENCE (CONTINUED)

SUBROUTINE / COMMON REGION	SIZE	ACCELT	ACCEN	BEAM	CFORCE	DERTV	DOATJ	GENMOD	IC	ICINPT	INPRNT	INPRT1	INPT	INPTPL	INPUT	INTERP	KVR	LTCALC	MAIN	MODXDP	NETEOP	PREPLT	PRINT	RSIN	RSOUT	SMLOAD
IBALL	50										*				*											
ICDFLG	8			*							*				*				*							
ICDX	13B0							*	*	*	*								*	*						
ICNETF	F48								*								*		*		*					
INAC	A284	*						*			*		*		*	*										
INCF	DC8				*			*			*				*											
INCFIC	8				*			*	*		*				*						*					
INDEAC	4	*		*		*		*			*				*			*			*					
INIC	CD8			*		*	*	*	*		*				*		*	*		*	*					*
INIDCP	280		*	*	*	*	*	*	*		*				*		*	*		*	*		*			*
ININPR	24										*				*								*			
INOUT	E										*				*								*			
INPR	8			*	*	*		*	*		*				*			*	*		*		*	*	*	
IPIC	4								*		*				*						*					
IRDE	8			*		*					*							*								
IUNAST	4														*		*									
KRUL	1E00			*															*					*	*	
LTC	4240					*	*				*				*			*	*							
LTCI	209C					*	*				*				*			*	*							
MACF	3E84				*			*											*					*	*	
MACFIN	C			*	*	*		*			*				*			*	*			*				
MADE	4B04			*		*												*	*					*	*	
MAPR	12CC																		*				*	*	*	
MAPR1	976																		*				*			
MASSES	460					*	*	*	*		*		*	*	*				*		*		*			
MAX	2B98			*		*												*					*	*	*	
MCFIII	8		*	*	*	*			*		*				*			*	*		*		*			*
METPIN	290C			*		*		*			*				*			*	*							
NHIUGH	144							*			*				*				*							
NP00I2	320			*	*	*	*	*	*	*	*				*		*	*	*	*	*		*			
NP00I4	4			*	*	*	*	*	*	*	*				*		*	*	*	*	*		*	*	*	
NP00R8	4B0			*	*	*			*									*			*					
NP01I2	F0			*	*	*		*	*		*				*			*			*		*			
NP01R8	1C20			*		*	*		*									*			*		*	*	*	
NP02I2	780							*			*				*											
NP02R8	4B0				*		*	*	*		*				*		*			*	*					
OLEO	82C			*		*		*	*		*				*		*	*			*			*	*	
OTPLT	F72														*				*			*	*			
PPLTS	4CA										*				*								*			

TABLE 4-1. KRASH85 SUBROUTINE/COMMON REGION REFERENCE (CONTINUED)

COMMON REGION \ SUBROUTINE	SIZE	ACCELT	ACCEN	BEAM	CFORCE	DERIV	DOATJ	GENMOD	IC	ICTNPT	INPRNT	INPRT1	INPT	INPTPL	INPUT	INTERP	KVB	LTCALC	MAIN	MODXDP	NFTFOR	PRFPLT	PRTMT	RSIN	RSOUT	SMLDAD
PRALL	4																		*				*			
PRMA	2490			*		*												*	*				*	*	*	
PRNFAC	4B00																				*		*			
RESTRT	30			*		*					*				*			*	*							
SMLDS	1004										*				*											*
STUFF	3A0							*			*										*					
UB	70C			*		*		*			*				*		*	*	*							
UBICD	E10																*									
UBIUNA	258														*		*									
VARINT	40			*		*					*				*			*	*				*			
VBEAM	258			*		*	*	*			*						*	*					*			

REFERENCES

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2. Gamon, M. A., Wittlin, G., "KRASH User's Manual, Input-Output, Techniques and Applications," Lockheed-California Company, FAA-RD-77-189II (Revised), Sept. 1979

APPENDIX A

SHOCK STRUT ELEMENT DESCRIPTION

A.1 GENERAL

The use of a shock strut element in KRASH is available for, but not limited to, lending gear oleo struts. The following discussion will be oriented to landing gear oleo strut usage. The axial strut motion is assumed to be uncoupled from the transverse displacements. Axial forces are produced by an air spring force, F_{A_i}, a hydraulic damping force, F_{O_i}, a friction force, F_{F_i}, and forces produced by elastic stops which limit the travel of the piston within the cylinder at full extension and full compression. Each of these forces is discussed separately.

A.2 AIR SPRING FORCE

The expression for the air spring force is

$$F_{A_i} = F_{A_{O_i}} \left(\frac{E_i}{E_i - y_i} \right)^{n_i} - F_{A_{A_i}} \qquad (A.1)$$

where

E_i = effective total strut cylinder length (Figure A-1)

$F_{A_{O_i}}$ = strut air preload at $y_i = 0$

$F_{A_{A_i}}$ = cylinder load due to ambient air

n_i = polytropic exponent

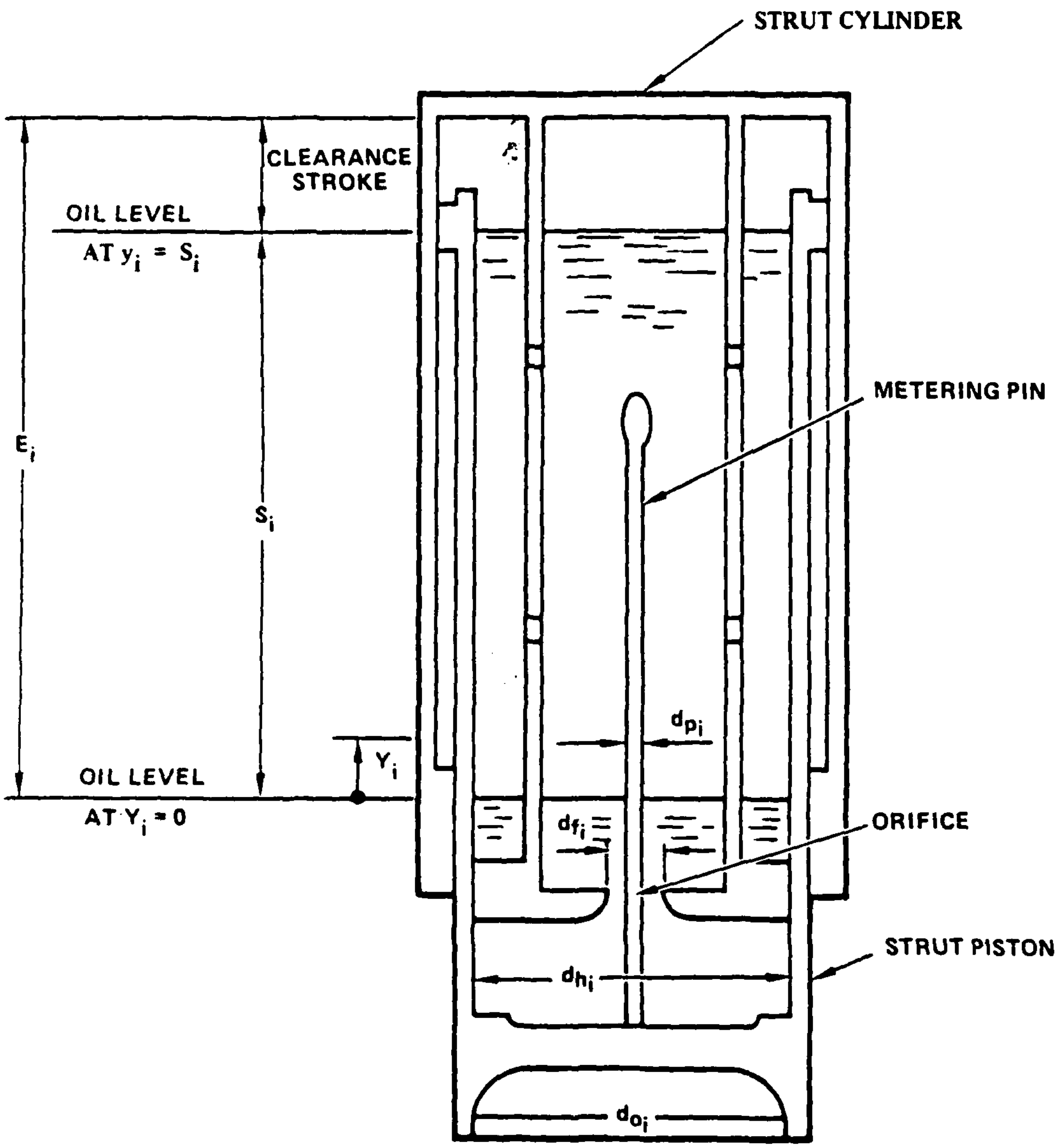

FIGURE A-1. SCHEMATIC OF OLEO STRUT

y_i = shock strut closure displacement, varying with time $F_{A_{o_i}}$ is given by

$$F_{A_{o_i}} = \pi/4 \left(p_{oi} \, d_{oi}^{\,2} \right) \tag{A.2}$$

where p_{oi} is the absolute air pressure in the upper chamber of the shock strut at full extension ($y_i = 0$) and d_{oi} is the effective pneumatic diameter as shown in Figure A.1.

If $F_{A_{s_i}}$ is the strut bottoming load at $y_i = s_i$, the value of E_i can be obtained from equation (A.1) as

$$E_i = \frac{S_i}{1 - \left(\dfrac{F_{A_{o_i}}}{F_{A_{s_i}} + F_{A_{A_i}}} \right)^{1/n_i}} \tag{A.3}$$

where S_i is the stroke. For high velocity impact conditions, a polytropic exponent of 1.4, representing adiabatic conditions, is appropriate.

In the program the values of E_I, $F_{A_{o_i}}$, $F_{A_{A_i}}$, S_i and n_i are input as EOLEO, FAO, FAA, YMAX and EXPOLE, respectively.

A.3 HYDRAULIC DAMPING

The hydraulic damping force F_{o_i} is given by

$$F_{o_i} = C_{z_i} \left| \dot{y}_i \right| \dot{y}_i \tag{A.4}$$

where

$\dot{y}_i$ = shock strut closure velocity, varying with time

$|\dot{y}_i|$ is the absolute value of $\dot{y}_i$ and C_{z_i} is a damping constant which is a function of the strut orifice characteristics B_i and of the characteristics B_{r_i} of a strut rebound valve. C_{z_i} is defined as

$$
\begin{aligned}
C_{z_i} &= B_i \text{ if } \dot{y}_i \geq 0 \\
C_{z_i} &= B_i + B_{r_i} \text{ if } \dot{y}_i < 0
\end{aligned}
\tag{A.5}
$$

B_i is defined by

$$
B_i = \frac{\gamma A^3_{h_i}}{2g\ (A_{f_i} C_d)^2} \tag{A.6}
$$

where

$A_{f_i} = \pi/4\ (d_{f_i}^{\ 2} - d_{p_i}^{\ 2}) =$ net orifice area

$C_d =$ orifice discharge coefficient (typical value = 0.85)

$\gamma/g =$ oil density (typical value = 0.992 E-4 $\frac{\text{lb-sec}^2}{\text{in}^4}$)

$A_{h_i} = \pi/4 \left(d_{h_i}^{\ 2} \right) =$ effective hydraulic area

d_{f_i}, d_{p_i} and d_{h_i} are the orifice, metering pin and effective hydraulic diameters, respective (see Figure A.1).

B_i and B_{r_i} are input into the program as BOLEO and BROLEO. A metering pin can be modeled by inputting a table of BOLEO versus YOLEO. YOLEO is the oleo compression, y, measured from the fully extended position.

Another feature of KRASH is the ability to solve for the metering pin shape that yields a desired oleo load-deflection characteristic curve. If this option is employed, the metering pin input table (POLEO versus YOLEO) is

interpretted as a table of total axial oleo load (F_i in equation A.10) versus oleo compression. This option is termed the inverse metering pin option, and is employed by specifying a negative number for MPTAB on card 1400. The inverse metering pin coding is useful for two situations.

- Landing gear drop data are available, but the basic gear data (metering pin shape) is not. KRASH can be used to calculate the variation of BOLEO versus YOLEO that will duplicate the observed test data, which is used as input data with the inverse metering pin coding. Once the BOLEO vs YOLEO data is calculated and output by KRASH, it can be used as input data for subsequent runs to analyze different conditions involving that gear.

- Metering pin design studies can be conducted using KRASH with the inverse metering pin option. In this situation, a metering pin characteristic can be determined that will yield a specified ideal oleo load-deflection curve.

When the inverse metering pin option is employed, the KRASH output data includes a table of YOLEO vs. BOLEO for each oleo specified. The data point spacing for the table is determined by the output point times specified by DP/DT on card 110. The data will be output in uniform time steps, which means that the YOLEO increments will not be uniform.

A.4 FRICTION FORCE

Coulomb friction is modeled, so that the magnitude of the friction force is independent of velocity, while the direction of the force is opposite to the direction of the strut velocity.

The friction forces, F_{F_i}, are given by

$$F_{F_i} = C_i f(\dot{y}_i) \tag{A.7}$$

where $f(\dot{y}_i)$ is a function whose sign is always equal to that of $\dot{y}_i$ and whose magnitude is 1.

Strictly speaking, $f(\dot{y}_i)$ should be equal to 1.0 for all positive values of $\dot{y}_i$ and equal to -1.0 for all negative values of $\dot{y}_i$. However, since the

friction force is a passive force and is only present as a reaction to an applied force, the friction force will be able to attain its full value only if the applied force is greater than C_i. If this situation is not the case, stops will occur in the motion. A rigorous treatment of this problem would introduce unwarranted complications into the program. A very good approximate solution which avoids the difficulty can be obtained by letting the friction force vary sufficiently slowly from C_i to $-C_i$ at small values of $\dot{y}_i$, so that at each step in the integration process equilibrium of the forces is obtained without introducing large discontinuities. The following form is therefore assumed for $f(\dot{y}_i)$:

$$f(\dot{y}_i) = \tanh(\dot{y}_i/\alpha_o) \qquad (A.8)$$

This function is plotted in Figure A-2 for various values of α_o. The value of α_o should be small enough to simulate the friction force with sufficient accuracy, but not so small as to introduce discontinuities. The minimum value will depend on the integration interval. Generally a value of $\alpha_o = 1$ is found to be suitable. The expression for the friction force becomes

$$F_{F_i} = C_i \tanh(\dot{y}_i/\alpha_o) \qquad (A.9)$$

The values of α_o and C_i are input as ALPHAP and FCOUL in the program.

A.5 ELASTIC STOPS

Two elastic stops of stiffness K_{E_i} and K_{c_i} are present which limit the travel of the piston at full extension and full compression, respectively. The forces generated by these stops are, therefore, equal to $K_{E_i}\, Y_i$ when $y_i < 0$ and $K_{c_i}\,(y_i - S_i)$ when $y_i > S_i$.

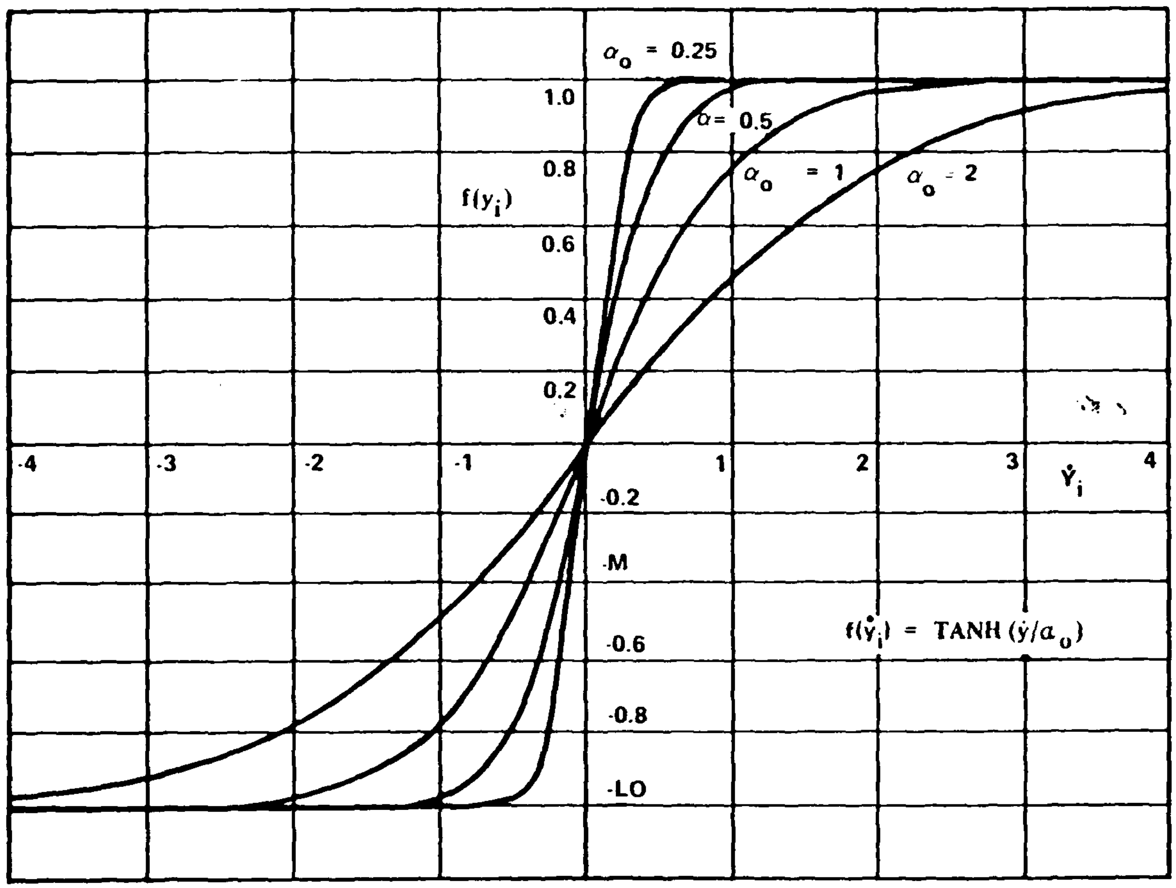

FIGURE A-2. FRICTION FORCE COEFFICIENT AS FUNCTION OF STRUT CLOSURE VELOCITY

Collecting all the above terms the total axial force F_i can be written as

$$F_i = F_{A_i} + F_{o_i} + F_{F_i} + F_{EXT_i} + F_{COMP_i} \qquad (A.10)$$

The terms K_{E_i}, K_{c_i}, and S_i are input into the program as XKEXT, XKCOMP, and YMAX, respectively.

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